Answers

Section 1. Principles of physics

P1a Units

Page 11

1. Length, time, mass.

2. So that the unit remains constant and science remains comparable.

3. a) Base: kilogram, second, metre.

   b) Derived: metre/second, newton.

P1b Movement and position

Page 14

1. Stationary – the distance does not change as time increases.

2 A straight line – positive gradient for moving away, negative gradient for moving towards.

3. Student's own graph – likely to be a curve, as shown in Fig. 1.2.

Page 15

1. 10000/(15 × 60) = 10000/900 = 11. 1 m/s.

2. 22.5 m.

3. 3000 s = 50 minutes.

Page 16

1. Speed describes how far an object travels in a particular time. Velocity is numerically identical to speed, but it also includes a statement of the direction of the travel.

2. The sign of a velocity indicates a direction. ‘Positive’ and ‘negative’ velocities are in opposite directions to each other. We still need to explain which direction we are taking to be positive – this will change depending on the motion we are studying. For example, if we are looking at the motion of objects acting under the force of gravity, we might say upwards is the positive direction, so that downwards becomes the negative direction.

3. a) Diagram showing tennis ball moving upwards with a speed of +5 m/s.

   b) Diagram showing tennis ball moving downwards with a speed of –5 m/s.

Developing investigative skills, pages 16–17

1. Extra friction provided by pulling the tape along / through the ticker timer would reduce the acceleration (and the trolley may reach a constant speed if the drag was enough to balance the force pulling the trolley down the slope).

2. An alternative approach could be to video the trolley rolling down the ramp and then measuring the position frame by frame on playback. This would need a scale to be attached alongside the ramp for measurements. Using light-gates would be more difficult, since a lot would be needed if the motion of the trolley was to be studied all the way down the ramp.

3. Table completed.

4. Graph starts at the origin and curves upwards, indicating an increase in speed as the trolley moved down the ramp.

5. Table completed.

6. Graph starts at the origin and provides a (reasonably) straight line indicating a (reasonably) steady increase in speed.

7. The data point for 0.6 s looks to be incorrectly calculated as it is significantly above the pattern of the other points on the speed-time graph.

8. If yes – would allow averages to be taken, ironing out some of the random friction effects of pulling the tape through. If no – not possible to repeat exactly as the friction from the tape / path of the trolley would be slightly different each time.

Page 19

1. Acceleration = (change in velocity)/ (time taken) = rate of change of velocity.

2. Deceleration.

3. 10 m/s^2

4. –15 m/s^2

Page 20

1. Constant velocity or speed in a straight line.

2. The line will be a straight line (constant gradient) – positive gradient for speeding up, negative gradient for slowing down.

3. Acceleration.

Page 22

1. The acceleration is the gradient of the graph.

2. The distance travelled is the area under the graph.

3. a) Athlete A: 8 m/s, athlete B: 6.25 m/s.

   b) Athlete A: horizontal line at 8 m/s, starting at 0 s and finishing at 50 s. Athlete B: horizontal line at 6.25 m/s, starting at 0 s and finishing at 64 s.

4. Area under speed-time graph is the same, i.e. 8 m/s × 50 s = 6.25 m/s × 64 s.

5. 45 m.

Page 23

1. 10 m/s.

2. The object is travelling at a steady speed.

3. C and D.

4. It is decelerating.

5. 120 m.

6. 10 m/s^2

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	0.36 km/minute	1 mark

2	5 m/s	1 mark
3	–6 m/s +4 m/s	1 mark 1 mark
4	1.25 m/s	1 mark
5 a)	10 km/h/s	1 mark
5 b)	2.78 m/s^2	1 mark
6 a)	the cars move along the road in the same direction, a constant distance apart	1 mark
6 b)	if they are moving towards each other, they will collide head on. If they are moving apart, they will continue to do so	1 mark
6 c)	the cars will move along the road, a constant distance apart in the opposite direction to a)	1 mark
7	zero you had a positive velocity in on your way to school and then a negative velocity on your way back from school. The two cancel out	1 mark 1 mark
8 a)	10 m/s	1 mark
8 b)	160 m	1 mark
8 c)	7.2 m/s work out the total distance by adding the 200 m and the 160 m together. Work out the total time by adding up the time for each section – don't forget to include the time waiting at the junction	1 mark
9	a graph will have axes which are labelled properly with a scale, plotted data points and the best line a sketch graph is drawn to illustrate the main shape of the line. Only key values such as where the line changes direction, will be given on the axes	1 mark 1 mark
10	using the usual way of labelling the axes, moving away has a positive gradient and moving towards you a negative gradient	1 mark 1 mark
11 a)	the speed remained constant if the line on a distance–time graph has a constant gradient then the speed is constant	1 mark
11 b)	600 m this can be read off the graph: after 20 s the car had travelled 200 m, after 60 s it had travelled 800 m. So the distance travelled is 830 – 250 = 580 m	1 mark
11 c)	15 m/s – answer must include units speed = distance/time, v = 580/40 = 14.5 m/s < 15 m/s.	1 mark
11 d)	it stopped the line is horizontal during this time, indicating that the car was not moving (no distance was travelled)	1 mark
12 a)	2.0 m/s^2	1 mark
12 b)	½ x (0.75 x 1.5) + ½ x (2.25 x 1.5)	1 mark

	2.25 m	1 mark
	Total:	26 marks

P1c Forces, movement, shape and momentum

Page 29

1. Effects – forces can change the speed of an object, the shape of an object, the direction the object is moving in. Types of force – gravitational, electric, magnetic, (electromagnetic), strong nuclear force.

2. Gravity.

3. The mass of objects and the distance between their centres.

4. In the nucleus.

5. Electromagnetic force.

Page 32 (top)

1. Vector has size and direction, scalar just has size.

2. Draw them to scale, joining them in turn ‘head to tail’. The final, or resultant, vector is drawn from the ‘tail’ of the first vector to the ‘head’ of the last one.

3. 2560 N.

Page 32 (bottom)

1. Walking, driving – if there is no friction, you skid.

2. Where energy transferred to thermal energy which is lost to the surroundings.

Page 34

1. The object will be stationary or moving in a straight line at constant speed.

2. The object will be changing speed and/or direction.

3. His weight.

Page 36

1. Force = mass × acceleration.

2. The force must be the resultant force, the mass must remain constant.

3. 600 N.

4. 800 m/s^2

Page 37

1. Mass amount of matter, weight force.

2. 600 N.

3. 50 kg.

Page 38

1. The different planets have different masses and so they have different gravitational field strengths. Since your weight = mass x gravitational field strength you will have a different weight (but the same mass) on different planets.

2. 96 N.

3. 50 kg.

4. 20 N on left hand side.

Developing investigative skills, page 40

1. The experiment only takes a matter of seconds. Watching the ball, observing its position (preferably by keeping your eyeline level with the ball to avoid parallax errors), looking at the clock, noting down the times and then refocusing on the ball would be very difficult for one person to do.

2. The students should use the same ball for repeat measurements. They should keep the temperature of the oil constant as changes in viscosity will affect the terminal velocity.

3. Graph drawn. Should be a smooth curve, beginning at the origin and flattening off at terminal velocity of 6.4 cm/s.

4. Should indicate the point where the line just becomes flat.

5. Larger ball is likely to reach terminal velocity more quickly as there will be more drag more quickly (assuming the ball is not very much larger or more massive). The terminal velocity will be higher as the more massive ball weighs more (so a bigger drag force will be needed to balance it).

6. If the oil is not too dark in colour, it might be possible to set a series of light gates at specific points alongside the tube to do the timing and/or calculate speeds. Also, could record on video and measure off frame by frame playback (taking care not to introduce parallax errors through the fixed position of the camera).

7. Simplest would be to note the position of the ball at specific times – i.e. reverse the roles of the two students. The one with the clock calls out on specific marks and the one watching the ball notes where it is. This allows the speed over specific time intervals to be calculated and plotted. It is possible to draw the relevant graph from the data the students already collected, however.

Page 41 (top)

1. a) velocity

   b) force

   c) acceleration.

2. The velocity graph decreases from initial zero until it reaches a constant value, which is the terminal velocity. The force graph includes the constant weight (the drag), which increases with time and then becomes constant; and the resultant, which is found by adding the weight and the drag. The acceleration graph increases initially and then reaches zero because the velocity has reached terminal velocity, which is not changing, so there is no acceleration.

Page 41 (bottom)

1. The velocity that an object, such as a skydiver, has when the forces are balanced so that the object travels at a maximum constant speed.

2. 10 m/s.

3. 15 N upwards.

4. 585 N downwards.

5. 9.75 m/s^2

Page 43 (top)

1. Thinking and braking distances both less.

2. Yes, reaction time faster.

3. Velocity at 30 km/h = 8.3 m/s, at 45 km/h = 12.5 m/s. In both cases acceleration = 6.5 × 103/1000 = 6.5 m/s^2. At 30 km/h, time = 8.3/6.5 = 1.28 s, so distance = 5.3 m. At 45 km/h, time = 12.5/6.5 = 1.92 s, so distance = 12 m.

4. Student's own response.

Page 43 (bottom)

1. Thinking distance: Any one of: Speed, fatigue, use of medication/drugs/alcohol, level of distraction. Stopping distance: Speed, weather condition of road, amount of tread tyres, friction from brakes, mass of car.

2. 36 m.

3. 18.

4. 7.5 m.

5. It would increase.

Page 44

1.The size of the force and the distance between the line of the force and the turning point, which is called the pivot.

2. 2 N m.

3. 1.25 N m.

4. 0.4 m.

Page 47

1. The centre of gravity is the point where we can assume all the mass of an object is concentrated.

2. Student's own description based on method described in the text.

3. No, it will fall over.

Page 49

1. 1.5 m.

2. 20 N each.

3. F_4 = 16 N, F_3 = 24 N.

Page 54

1. 0.01 N.

2. 0.05 N/cm.

3. 20 cm.

Developing investigative skills, page 55

1. Risk of the spring unwinding at either end, causing the masses to be dropped and the spring to fly up.

2. Risk of toppling over – stand can be fixed to the table using a G-clamp. Risk of masses falling and damaging feet or floor – minimize risk by having soft material available in landing area and keep feet out of the way.

3. Preliminary experiment helps to judge the values of mass needed to achieve measurable extensions with this kind of spring. In general, preliminary ('trial') experiments give an idea of how the experiment will run so you know if it is worth the time and effort to follow the method particularly carefully.

4. Values in table, reading 1.0 N, 2.0 N, etc.

5. Values in table, reading 0 cm, 4 cm , etc.

6. Graph plotted – straight line up to the last two values where it curves away.

7. The spring obeyed Hooke's Law up to a point (at a load of 12 N). This is justified by referring to the graph being a straight line (up to that point) through the origin.

8. The spring had been permanently stretched, so could not be re-used for this experiment.

9. Add a marker, such as an optical pin, to the end of the spring. This can then be set against the ruler. If the marker is not exactly at the end of the spring it does not matter, since in this experiment the student is looking for *changes* in length.

Page 56

1. 2.32 kg m/s.

2. 50 000 kg m/s.

3. 1000 kg.

4. 25 m/s.

Page 61

1. Momentum = mass × velocity. Momentum is a vector quantity (it includes a direction) because velocity is a vector quantity.

2. From Newton's second law, for a particular change in momentum, the longer the change takes the smaller the force will be. So if a parachutist bends their knees when they land the landing takes a longer time, the momentum change is fixed and so the force is reduced.

3. 2.5 m/s.

4. 4 m/s.

5. a) 100 000 kg m/s.
   b) 100 000 kg m/s.
   c) 10 m/s.

Developing investigative skills, page 64

1. Make sure the ruler is perpendicular to the table top (by using a set square) and measure the height in several places across the ramp.

2. The student also needed to know the mass of the trolley as momentum = mass × velocity. The mass could be measured using a balance.

3. Independent variable: height of ramp; dependent variable: time take for trolley to go down ramp.

4. Graph.

5. As the height increases, the momentum increases. It is not directly proportional.

6. On their own, these data points would indicate a line, probably straight, giving a *y*-intercept of about 0.6 kg m/s (assuming momentum is on the *y*-axis).

7. You would expect the line to go through the origin as a ramp of starting height of zero will mean no momentum is gained by the trolley.

8. The student should make additional measurements between 0 cm and 15 cm to gather more data points and make the pattern in the line clearer in this region. (In practice, the student found it difficult to make these measurements as the friction tended to slow the trolley down too much).

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	600 N	1 mark
1 b)	60 kg	1 mark
1 c)	228 N	1 mark
1 d)	60 kg	1 mark
1 e)	228 N	1 mark
2 a)	stay similar because the force your muscles exert does not change	1 mark 1 mark
2 b)	increase because the force used to jump the same height is now less	1 mark 1 mark
2 c)	increase because the force used to vault to the same height is now less	1 mark 1 mark
2 d)	increase because the force used to throw the javelin the same distance is now less	1 mark 1 mark
2 e)	probably stay similar because speed depends on air resistance which has not changed [there is a case for decrease if, for example, jumping along turned out to be faster than running]	1 mark 1 mark
3 a)	stage 1 – the skydiver is accelerating. The downward weight is greater than the upward force caused by air resistance stage 2 – the skydiver is travelling at constant speed. The weight and air resistance are balanced stage 3 – the skydiver is slowing down. The force caused by the air in the parachute is greater than the weight stage 4 – the skydiver is travelling at a constant speed. The forces are balanced again	1 mark 1 mark 1 mark 1 mark
3 b)	the weight is balanced by the upward force of the ground on the skydiver	1 mark
4 a)	the graph is a straight line from the origin to the (12 cm, 6.0 N) point after that it become increasingly curved and less steep	1 mark 1 mark
4 b)	the limit of proportionality should be marked on the graph at the end of the region that is a straight line proportional behaviour occurs all along the region where the graph is a straight line. Plastic behaviour occurs thereafter, though not necessarily immediately	1 mark 1 mark
4 c)	if the spring returns to its original length then the behaviour was purely elastic. If it is longer, then the behaviour was partially elastic and partially plastic	1 mark
5 a)	2.5 m/s^2	1 mark
5 b)	2500 N	1 mark

Question	Correct answer	Marks
6 a)	5000 N, approximately north east	1 mark
6 b) i)	acceleration = force/mass = 5000 N/500 000 kg = 0.01 m/s^2	1 mark
6 b) ii)	change in speed = acceleration × time = 0.01 m/s^2 × 10 s = 0.1 m/s	1 mark
7	800 Nm	1 mark
8	C C has the widest base and is heavier at the bottom (more glass)	1 mark 1 mark
9	Ahmed's clockwise moment is 300 N × 4 m = 1200 Nm. Rod's anticlockwise moment is 450N × 4 m = 1800 N m. Freddy needs to provide a moment of 600 N m clockwise to balance the see-saw. Freddy weighs 300 N, so he needs to sit 2 m to the right of the pivot (300N × 2 m = 600 N m)	1 mark 1 mark
10	acceleration = rate of change of velocity. As changing direction changes the velocity	1 mark
11	the Moon orbits the Earth and the Earth orbits the Sun the force causing this is gravity	1 mark 1 mark
12	balanced = steady speed no resultant force	1 mark 1 mark
13	unbalanced – slowing down so there is a resultant force	1 mark 1 mark
14	acceleration = 2 m/s^2, resultant force = 3000 N this is an average because the actual force will have varied over time as the frictional forces varied	1 mark 1 mark
15	resultant force = force from engine – frictional forces (opposing motion) 3000 N = force from engine – 200) N force from engine = 5000 N	1 mark
16	lower gravitational field strength so time of flight is longer as vertical acceleration is lower also lack of air resistance means no horizontal deceleration	1 mark 1 mark 1 mark
17	gravity causes drops to accelerate down. as the speed increases, drag increases until resultant force is zero at this point raindrop falls at constant speed (terminal velocity). So raindrop gains no further kinetic energy	1 mark 1 mark 1 mark
18	list of factors on pages 41–42 with explanations as to why they make a difference in changing the reaction time (factors to do with the driver) and those relating to friction (brakes, road surface etc)	3 marks max (1 mark per correct factor and explanation)
19 a)	7500 kg m/s	1 mark
19 b)	1500 N	1 mark
19 c)	forces of friction between the car and the road, air resistance	1 mark
20	the skateboard can move	1 mark

Question	Correct answer	Marks
	so there must be the same momentum going backwards as there is going forwards	1 mark
21	moment = force × distance from pivot, so pushing opposite to the hinge increases the distance	1 mark
	and less force is needed to get the same moment	1 mark
22	heavy base: centre of gravity lower	1 mark
	wide base: has to top further before the centre of gravity moves outside the pivot causing the vase to topple over	1 mark
23	yes, if the graph of force against extension is a straight line. Rubber will follow the proportional path until the polymer chains are more straightened out	1 mark
	however a sample of rubber may need a little extra force to get started and so not follow the straight line all the way to the origin	1 mark
24	stiff springs: reduce body roll, go round corners faster soft springs: absorb the bumps better, more comfy ride	1 mark
	so choose stiff springs	1 mark
	Total:	67 marks

P1d Astronomy: our place in the Universe

Page 70

1. Mercury, Venus, Earth, Mars, Jupiter, Saturn, Uranus, Neptune.

2. Inner four = solid, outer four = gaseous.

3. A planet is an object that orbits the sun and is large enough to have become round due to the force of its own gravity. A planet also has to dominate the neighbourhood around its orbit.

4. Pluto does not dominate its neighbourhood. It is only about double the size of its large ‘moon’ Charon, but all the true planets are far larger than their moons. Also, planets that dominate their neighbourhoods ‘sweep up’ asteroids, comets, and other debris, clearing a path along their orbits. Pluto does not.

Page 73

1. Diagram of Solar System with central Sun, a planet in circular orbit around it, a moon in circular orbit around the planet and a comet in highly elliptical orbit around the Sun.

2. Moons are objects that orbit planets rather than the Sun, as planets and comets do.

3. Scientists think that a small planet collided with the Earth soon after it was formed 4.5 billion years ago, forming our Moon.

Page 74

1. a) 28 000 km/h

   b) 7795 m/s

2. 7900 m/s

3. 1021 m/s

Page 75

1. 96 N on the Moon, 1560 N on Jupiter.

2. They weigh less on the Moon, but there is gravity there (or else they would float off into space if truly weightless).

3. 546 N.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	nearly circular	1 mark
1 b)	elliptical	1 mark
2 a)	some of the ice and other materials evaporate as comet gets closer to sun and form the tail	1 mark
2 b)	pushed by the solar wind, stream of particles emitted by the Sun	1 mark
2 c)	moves faster when it is closer to the Sun	1 mark 1 mark
3 a)	any object that which is in orbit around another	1 mark
3 b)	communications monitoring weather testing theories about global warming	1 mark 1 mark 1 mark
4 a)	3053 m/s	1 mark
4 b)	5450 m/s	1 mark
5 a)	weight depends on mass and gravitational field strength. Mass of an object remains the same on earth and on moon but gravitational field strength on moon much less than that on earth so object will weigh less on moon.	1 mark 1 mark
5 b)	112 N	1 mark
	Total:	15 marks

Section 1: Answers to exam-style questions

Question	Correct answer	Marks
2 a) i)	speed = distance ÷ time (or equivalent)	1 mark
2 a) ii)	speed = 100 ÷ 9.58 10.4 (m/s) 3 s.f. only	1 mark 1 mark 1 mark
2 a) iii)	this is an average slower at start	1 mark 1 mark 1 mark
2 b)	the runner must react to the start it takes time (0.1 s minimum)	1 mark 1 mark

Question	Correct answer	Marks
	for brain to process/get muscles to move	1 mark
3 a) i)	between 10s and 30s	1 mark
3 a) ii)	because the graph is horizontal	1 mark
3 b)	acceleration = gradient 8 ÷ 10 = 0.8	1 mark 1 mark 1 mark
3 c)	area under graph = distance; (1/2 × 10 × 8) + (20 × 8) + (1/2 × 15 × 8) 260 (m)	1 mark 1 mark 1 mark
4 a)	Any FIVE suitable points, for example: ruler to measure the height of the fall stopwatch/clock to measure time of fall measure time of fall for different areas keep height constant plot suitable graph	5 marks (1 mark for each point)
4 b)	Any FIVE suitable, connected points, for example weight pulling down so object accelerates so drag increases reducing resultant force so acceleration reduces when drag = weight speed is constant	5 marks (1 mark for each point)
5 a)	initially momentum is zero Alex has momentum in one direction after so Tom must have a negative momentum so that final momentum is zero overall	1 mark 1 mark 1 mark 1 mark
5 b) i)	momentum = mass × velocity (or equivalent)	1 mark
5 b) ii)	50 × 1.5 75 kg m/s	1 mark 1 mark 1 mark
5 b) iii)	– 75 (kg m/s)	1 mark 1 mark
5 b) iv)	75 ÷ 1.2 62.5 kg	1 mark 1 mark
5 c)	the force must be equal magnitude	1 mark

Question	Correct answer	Marks
	opposite in direction	1 mark
6 a) i)	$W = m \times g$	1 mark
6 a) ii)	2000 × 6 12 000 (N)	1 mark 1 mark
6 b) i)	container gives clockwise moment concrete block provides anticlockwise moment to balance	1 mark 1 mark 1 mark
6 b) ii)	clockwise moment = anticlockwise moment (12 000 × 12) = (W × 3) W = 48 000 (N) mass = 4800 kg	1 mark 1 mark 1 mark 1 mark
7 a)	hold vertically zero next to start of spring head at same height to avoid parallax errors	1 mark 1 mark 1 mark
7 b)	any ONE suitable, e.g. safety glasses in case spring flies up risk of masses falling	1 mark max.
7 c) i)	suitable scales plotting points suitable line	2 marks 2 marks 1 mark
7 c) ii)	anomaly identified does not fit pattern	1 mark 1 mark
7 c) iii)	yes straight line through origin	1 mark 1 mark 1 mark
8 a) i)	A	1 mark
8 a) ii)	D	1 mark
8 b)	88 days = 7.6×10^6 s; 58 million km = 5.8×10^{10} m orbital speed = $2 \times \pi \times 5.8 \times 10^{10}/7.6 \times 10^6$ = 47 950 m/s or 4.795×10^4 m/s	1 mark 1 mark 1 mark
8 c)	galaxy collection of billions of stars universe is a collection of billions of galaxies	1 mark 1 mark
	Total	73 marks

Section 2 Electricity

P2b Mains electricity

Page 94

a) 1.6 A, 3 A fuse.

b) 3.47 A, 5 A fuse.

c) 0.4 A, 3 A fuse.

d) 9.1 A, 13 A fuse.

e) 3.9 A, 5 A fuse.

Page 95

1. Brown wire: live, connected to fuse. Blue wire: neutral wire. Green and yellow wire: earth wire.
2. It melts when the current gets too high.
3. The student should not choose the 'nearest' fuse, but the 'nearest above'. If the appliance requires 6 A, the 5 A fuse will break whenever the appliance is used.
4. The earth connection needs to be a low resistance path (see later in the chapter). This means that a high current will pass through the wire and this will melt the fuse (or trip the circuit breaker).
5. The casing cannot become live because it is not a conductor.

Page 96

1. A resistor is a device that opposes the flow of current.
2. It increases.
3. Electrical energy to heat energy.

Page 98 (top)

1. 220 W
2. 12 V
3. 0.11 A

Pages 98–99

1. The charger will still work, although the battery may not charge as effectively. The transformer in the charger (see section 6) will reduce the mains voltage by the same factor, so the battery may not be able to charge fully.
2. The charger will reduce the mains voltage by the same factor as usual, but starting with 230 V, the resulting voltage may be high enough to damage the circuitry in the laptop.
3. 2160 J
4. 3.3 A
5. 218 s
6. 12 V

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	if the wire is carrying a larger current, the diameter must be bigger so that the wire does not get too hot	1 mark 1 mark
2	Only the live has a big enough voltage to kill. Once the fuse has blown, the supply voltage is disconnected, making the appliance safe to touch.	1 mark
3 a)	920 W	1 mark 1 mark
3 b)	Water greatly increases the hazard of any contact with mains electricity as the skin becomes highly conducting. If the hairdryer is dropped in the washbasin, then any attempt to pick it out will be fatal.	1 mark 1 mark
4	Current is 6.1 A, so a 13 A fuse should be used.	1 mark 1 mark 1 mark
5 a)	You should fit an MCB of 30 A	1 mark 1 mark
5 b)	You should fit an MCB of 40 A.	1 mark 1 mark
6	900 J	1 mark 1 mark
7 a)	5 A	1 mark 1 mark
7 b)	13 A	1 mark 1 mark
8	Current that flows is 6.67 A so the fuse is rather high in value.	1 mark 1 mark
9	0.05 A	1 mark 1 mark
10	352 W	1 mark 1 mark
11	111 V	1 mark 1 mark
	Total:	28 marks

P2c Energy and potential difference in circuits

Page 106

1. There is probably a break in the circuit.

2. In a parallel circuit, more energy is transferred each second – the bulbs are brighter. The energy available from the battery is limited by the chemicals used – running two bulbs at once at full power with transfer the chemical energy more quickly and the battery will become flat sooner.

3. So that they can be switched independently.

4. a) in a series, dimmer because battery energy shared between two bulbs.

   b) in parallel, full energy of battery given to each bulb.

Page 108-109

1. Bulb B has the higher resistance. The brighter bulb must have the higher current (since, in parallel, both bulbs are connected to the same voltage), so it must also have the lower resistance.

2. In series, bulb B will be brighter. It has a higher resistance, so in series it will have a bigger share of the voltage and hence the energy.

3. Use a circuit like the one shown in Fig. 2.22. Vary the voltage and record the current flowing in the circuit.

4. The ammeter should be connected in series and voltmeter in parallel with the component.

Page 112

1. In brighter light, the resistance of the LDR decreases, so the current in the circuit will increase. The ammeter reading will therefore increase in brighter light.

2. A diode has a low resistance if the current moves in one direction and a very high resistance in the other. A waterfall allows water to move easily in one direction, but the water cannot go 'backwards' up the waterfall. In this way the analogy is reasonable.

3. Increasing the temperature reduces resistance.

Developing investigative skills, pages 112–113

1. To make sure the water is all at the same temperature. The thermometer actually records the temperature of the water, so if the student is going to use this value as the temperature of the thermistor, she needs to ensure all the water is at the same temperature.

2. (a) the range of the thermometer is 60 ^{0}C and (b) when it records 40 ^{0}C the true value will be between 38 ^{0}C and 42 ^{0}C.

3. Graph.

4. As the temperature increases, the resistance decreases.

5. Similarly to Q1, the thermometer is actually measuring the temperature of the water. If the student wishes to use this value as the temperature of the thermistor, then she must allow time for the energy transfer between the thermistor and the water to reach equilibrium.

6. As the temperature increases the resistance decreases, so at higher temperatures it becomes easier to achieve a net transfer of electrons. Increasing the temperature would increase the average kinetic energy of the particles, but this would be in a random manner and would particularly apply to the large ions in the structure (which is why the resistance of a filament lamp increases as the temperature increases). In this case, the additional energy makes more electrons available to conduct which overwhelms the increased resistance due to increased particle vibrations leading to a decrease in resistance overall.

Page 114

1. 10 V

2. 6.0 Ω

3. The current would rise ever more slowly as the potential difference increased. This is because increasing the current makes the wire hotter, increasing the resistance.

Developing investigative skills, page 115

1. The method involves a comparison between the voltmeter reading and the ammeter reading. These will change in proportion (Ohm's Law) so the absolute values do not matter, the ratio will remain constant.

2. A zero error is where the meter has an incorrect reading when it should in fact read zero. To check the ammeter and voltmeter, the student should connect together the terminals of each meter – if the reading is not zero then the scale on the meter will need to be adjusted.

3. Graph drawn – best fit line should be a straight line through the origin.

4. Resistance is given by the gradient of the line drawn on the graph. The triangle used for the calculation should be clear on the graph and should be of a good size – generally a triangle spreading over at least half the graph line would be taken as the minimum acceptable.

5. Calculating the resistance from each pair of readings and then taking a mean would give equal importance to the particular values measured. When drawing the best fit line on the graph you can make a finer judgement about the value of each data point, weighting the line towards the more general pattern.

6. Heating effects can be reduced by actions such as carrying out the experiment at lower supply voltages and only completing the circuit for short periods of time when measurements are actually being made.

Page 117

1. a) 15 C

   b) 20 C

   c) 92 C

   d) 45 C

2. 9000 C

3. 120 s

Page 118

1. They flow in opposite directions.

2. The longer the wire, the further the electrons have to travel through the wire.

3. The thicker the wire, the more routes electrons have to travel through the wire.

4. 3*R.*

5. 1/3*R.*

Page 122 (top)

1. Students' own answers. One possible answer is that the current is the amount of water flowing, the potential difference is height the water is pumped up. The ammeter measures the amount of water flowing past the water wheel, the voltmeter measures the height difference. A series circuit would have two or water wheels connected one after the other, a parallel circuit would have two or more water wheels connected side by side.

2. Students' own answers. One possible answer is that it is a good model, but does not model the way current is affected by resistance in series and parallel circuits. The amount of water flowing relies on how much water the pump is pumping.

Page 122 (bottom)

1. The battery or power source.

2. They transfer the energy to the components in the circuit.

3. The difference in voltage between the two points.

4. Yes, potential difference is the difference in energy of a coulomb of charge between two points in a circuit.

5. The electrons at the point with the higher voltage will have more energy than the electrons at the point with the lower voltage.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	A_1 reading 0.2 A A_2 reading 0.2 A. The current is always the same at any point in a series circuit	1 mark 1 mark
1 b)	A_4 reading 0.30 A A_5 reading 0.15 A. The ammeter A_6 has been placed on one branch of the parallel circuit. Ammeter A_5 is on the other branch. As the lamps are identical the current flowing through them must be the same. Ammeter A_4 gives the current before it ‘splits’ in half as it flows through the two parallel branches	1 mark 1 mark
2	reading on V_1 = 6 V. The potential difference across the battery is 9 V. This must equal the total PD in the circuit. Assuming there is no loss along the copper wiring the PD across the lamp must be 9 – 3 = 6 V	1 mark 1 mark
3 a)	$I = Q/t$, I = 10/30 = 0.33 A	1 mark 1 mark
3 b) i)	10 C	1 mark 1 mark
3 b) ii)	36 000 C	1 mark 1 mark
4 a)	24 V	1 mark 1 mark
4 b)	20 V	1 mark 1 mark
4 c)	0.12 A	1 mark 1 mark
4 d)	23 A	1 mark 1 mark
4 e)	60 Ω	1 mark 1 mark
4 f)	23	1 mark

Question	Correct answer	Marks
	Ω	1 mark
5 a)	the battery	1 mark
5 b)	the voltage will increase, and so will the current	1 mark
5 c)	it will decrease	2 marks
5 d)	1.5 V	1 mark 1 mark
6 a)	a line graph with voltage on the *x*-axis and current on the *y*-axis	1 mark 1 mark
6 b)	voltage	1 mark
6 c)	they are consistent but he only took one set of readings	1 mark 1 mark
6 d)	he could have repeated them he could have recorded more values	1 mark 1 mark
6 e)	correctly plotted graph resistance = 3.5 Ω	2 marks 1 mark
7	row 1: 0.3 (V) row 2: 30 (Ω) row 3: 6 (V) row 4: 4 (Ω) row 5: 13 (12.97) (A)	1 mark 1 mark 1 mark 1 mark 1 mark
8 a)	$A_1 = A_2 = 0.3$ A; $V_1 = V_2 = 1.5$ V. The current through each lamp would be the same but the potential difference across each lamp would be different	2 marks 1 mark 2 marks 1 mark
8 b)	$A_1 = A_2 = 0.15$ A; $V_1 = V_2 = 3.0$ V. The potential difference across each lamp would be the same, but the current through each lamp would be different	2 marks 1 mark 2 marks 1 mark
9 a)	series	1 mark
9 b)	parallel	1 mark
9 c)	parallel	1 mark
9 d)	series	1 mark
9 e)	series	1 mark
9 f)	parallel	1 mark
9 g)	parallel	1 mark

Question	Correct answer	Marks
9 h)	series	1 mark
10 a)	positions of ammeters and voltmeters should be reversed	1 mark 1 mark
10 b)	potential difference across variable resistor (V), potential difference across lamp (V) current through main circuit (A), current through lamp (A)	1 mark 1 mark
	Total:	69 marks

P2d Electric charge

Page 132

1. You are the insulator. You will have rubbed electrons either onto or off yourself, perhaps by sliding your feet over a carpet. The metal handrail is a conductor – when you touch it, it allows the electrons to move to restore the balance and this is what you feel as a shock.

2. Negatively charged.

3. Positively charged.

4. The key idea is friction – water droplets rubbing against each other, bit of dust, etc. Although water is a conductor, in a cloud it is isolated from the ground so the charge can build up.

Page 133

1. Electrons are extremely small and negatively charged. Electrons are also around the outside of atoms. These key ideas make it much easier for electrons to be moved about (than the positively-charged parts of the atom) to account for all the electric effects we know.

2. The electron clouds in your feet repel the electron clouds in the floor. The force of repulsion is easily enough to stop you falling through.

3. a) Polythene rod should be negatively charged and cloth positively charged. Perspex rod should be positively charged and cloth negatively charged.

   b) They will be equal and opposite.

Developing investigative skills, page 135

1. Any suitable suggestion – for example, place a large protractor directly behind the stream of water, lined up so that the undeflected stream follows the zero line. Method should mention taking measurements from directly in front to avoid parallax errors.

2. Any suitable suggestion – for example, place a beaker below the stream and measure the volume of water collected over a set time. The volume collected should remain constant when the measurement is repeated if the stream is at a constant flow.

3. The independent variable is the ‘amount’ of charge on the rod, the dependent variable is the angle of deflection (of the water stream).

4. In this case, the student cannot say exactly what the charge on the rod is in coulombs. All the student can do is compare the strength of the effects produced by different charges – that is, the charge on the rod *relative* to the other rods.

5. The distance of the rod from the stream will also affect the angle of deflection – it is a variable that needs to be controlled and kept constant. At the moment, the method does not make it clear how close the student means to bring it or how they will measure it.

6. The charged rods will induce a charge on the water stream. The side nearest the charged rods will always be induced with the opposite charge to the rods. So the stream will always be attracted to the rod whether it is positively charged or negatively charged – the student will not be able to use this test to distinguish between the types of charge.

Page 139

1. Any suitable example such as combing your hair, touching a door knob or a car.

2. Movement of charge from clouds to the ground.

3. Any suitable example such as electrostatic scrubbers in power station chimneys, vacuum cleaners, inkjets and photocopiers.

4. They can both attract or repel objects.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	electrons are rubbed off the surface of the plastic onto the cloth	1 mark
	static electricity is produced by removing electrons from one insulator to another. An excess of electrons leads to a negative charge	1 mark
1 b)	the positively charged rod induces a negative charge on the surface of the paper near to the rod	1 mark
	opposite charges then attract	1 mark
2 a)	the passenger is charged by friction as her clothes rub against the seat covers. The car is also charged by friction with the road and the air	1 mark
	touching metal allows the charge to flow to earth	1 mark
2 b)	touching a door handle after walking on a synthetic carpet	1 mark
	removing clothing	1 mark
3	lightning	1 mark
	fuelling aircraft. Static electricity can cause explosions in any situations when there are fuels in the gaseous form	2 marks
4	hair to comb transfers charge	2 marks
	static electricity crackles	1 mark
	charge transferred comb to paper	2 marks
	enables attraction of paper	1 mark
5	nylon positive and rubber negative	1 mark
	will attract and so machine will not run smoothly	1 mark
	nylon and nylon will repel	1 mark
	so machine will run smoothly	1 mark
6	plastic comb/hair	1 mark
	duster and polythene	1 mark
	polyester clothes and hair	1 mark
	leather and rubber	1 mark
	and duster/glass rods	1 mark
	all collect charge	1 mark

Question	Correct answer	Marks
	which can be transferred	1 mark
	others do not collect charge	1 mark
7 a)	Jim: anti-static wrist strap	1 mark
	Rashida: anti-static clothing – trousers jackets made of materials that don't build up charge easily when rubbed	1 mark
	boots' anti-static properties	1 mark
	aircraft grounding strap	1 mark
7 b)	links to ground	1 mark
	discharge static safely	1 mark
7 c)	any suggestion where there is a build up of charge	1 mark
	could be hazard to person or environment	1 mark
7 d)	spark igniting fuel or fumes	1 mark
7 e)	any material that does not build up charge – cotton	1 mark
	nylon and leather	1 mark
7 f)	conductive	1 mark
	charge can flow through them	1 mark
7 g)	less humid	1 mark
	charge can't dissipate so easily	1 mark
	Total:	44 marks
1 a)	electrons are rubbed off the surface of the plastic onto the cloth	1 mark
	static electricity is produced by removing electrons from one insulator to another. An excess of electrons leads to a negative charge	1 mark

Section 2: Answers to exam-style questions

Question	Correct answer	Marks
2 a)	iron has resistance	1 mark
	energy transfer (by collisions)	1 mark
2 b) i)	$P = V \times I$	1 mark
2 b) ii)	$I = 1100 \div 230$	1 mark
	4.8 (A)	1 mark
2 c)	if current gets too high	1 mark
	fuse melts	1 mark
	breaking the circuit	1 mark
2 d) i)	iron has metal case	1 mark
	risk of shock	1 mark
2 d) ii)	if case becomes live	1 mark

Question	Correct answer	Marks
	provides low resistance path	1 mark
	so large current/fuse melts	1 mark
2 e)	AC – current changes direction	1 mark
	DC – electron flow always in one direction.	1 mark
3 a)	measure current and voltage	1 mark
	for different settings of variable resistor	1 mark
3 b) i)	line through origin	1 mark
	straight initially	1 mark
	becoming steeper	1 mark
3 b) ii)	as current increases wire becomes hotter	1 mark
	so resistance increases	1 mark
	so gradient increases	1 mark
3 c)	first part of graph/straight line	1 mark
	heating effect not enough	1 mark
	to change resistance	1 mark
3 d) i)	$V = I \times R$	1 mark
3 d) ii)	3 ÷ 15	1 mark
	0.2 (A)	1 mark
3 d) iii)	$Q = I \times t$	1 mark
3 d) iv)	0.2 × (10 × 60)	1 mark
	120	1 mark
	C	1 mark
4 a)	electrons transferred	1 mark
	gain = negative/loss = positive	1 mark
4 b)	conductor	1 mark
	allows electrons to leave/arrive	1 mark
4 c)	method to allow one rod to move freely (e.g. hang from thread)	1 mark
	bring second rod close	1 mark
	move together = attraction/move apart = repulsion	1 mark
	unlike charges attract/like charges repel	1 mark
4 d)	suitable example	1 mark
	hazard	1 mark
	risk reduction	1 mark
	Total:	44 marks

Section 3: Waves

P3b Properties of waves

Page 153

1. a) The waves travel by vibrations in the direction of travel of the wave.
   b) The waves travel by vibrations at right angle to the direction of travel of the wave.
2. a) The distance between consecutive peaks or troughs of the wave.
   b) The number of vibrations per second or number of peaks or troughs that pass a point each second.
   c) The size of the vibrations.
3. 15 m.
4. Energy.

Page 154

1. 1.2 m.
2. 3×10^8 m/s.
3. 1500×10^6 Hz.

Page 155

1. 0.002 27 s.
2. 8.33×10^{-7} s.
3. 4×10^{-8} s.

Page 157

1. An echo is a single reflection from a hard surface.
2. $v = f\lambda$, f constant, so if v reduced so must λ.
3. It depends on the change in speed.
4. They are comparable in size.

Developing investigative skills, page 158

1. The students are measuring short time intervals (as the speed of sound is quite fast). Their measurements also depend on the first student tapping out a rhythm exactly in time with the echoes. Reaction time is looked at in question six. All these elements suggest that anomalous results will be quite easy to generate, so repeat measurements, and plenty of them, would be wise in this case.

2. If the wall is 100 m away then the echo is obviously heard when the sound has travelled 200 m. This still takes less than one second and the timing will be quite difficult to do accurately by hand. However, if the distance is much further, then the energy from the sound wave will have dispersed over a wider area and the echo will be more difficult to hear. 100 m seems a reasonable compromise.

3. Speed of sound = distance travelled / time taken = (4 × 200m)/2.3 s = 350 m/s (to 2 s.f.)

4. To generate data for a graph, the students could measure the times between different numbers of echoes. For example:

Number of echoes	Distance (m) (number of echoes × 200)	Time interval (s)

This allows a graph to be plotted of distance on the y-axis against time on the x-axis. The speed of sound is then the gradient of the graph.

5. As mentioned in question one, there are a number of factors which could cause an individual measurement to be inaccurate. Plotting a graph would allow such measurements to be picked up more easily and the best fit line would allow such anomalies to be smoothed out.

6. Reaction times could affect the tapping out of the rhythm on the metal bar, since the student has to hear the echo to react to it. Also, the student timing has to react at the start of the measurement and at the end. All these reactions add uncertainty to the measurements.

7. A sound sensor connected to a data logger or a computer could reduce the effect of at least some of the reaction times.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	the diagram should show several sine waves the crest is the top of the wave the wavelength is the length of the repeating pattern the amplitude is half the distance between the crest and the trough	1 mark 1 mark 1 mark
1 b)	512 waves per second	1 mark
2 a)	0.33 m	1 mark 1 mark
2 b)	1.11×10^{-9} s	1 mark 1 mark
3 a)	0.75 m	1 mark 1 mark
3 b)	about 0.75 m	1 mark 1 mark
4	3×10^{9} Hz	1 mark 1 mark
5	80 m/s	1 mark 1 mark
6	completed table as shown	12 marks

Speed (m/s)	Frequency (Hz)	Wavelength (m)	Period (s)
20	10	2	**0.1**
20	5	**4**	**0.2**
30	**5**	6	0.2
340	**10**	34	**0.1**
160	8	**20**	**0.125**

<table>
<tr><th>Question</th><th>Correct answer</th><th>Marks</th></tr>
<tr><td></td><td><table><tr><td>3000</td><td>250</td><td>12</td><td>0.004</td></tr></table></td><td></td></tr>
<tr><td>7 a)</td><td>the water gets shallower
200 m
ahead</td><td>1 mark
1 mark
1 mark</td></tr>
<tr><td>7 b)</td><td>the current is going right to left
the waves make the piece of wood bob up and down
but they do not move it along</td><td>1 mark
1 mark
1 mark</td></tr>
<tr><td>7 c)</td><td>if this is so, mobile phone signals cannot penetrate the walls of your house and must come in through the windows
because mobile phones use short wavelengths, the waves cannot easily bend around buildings
hence unless your window is facing a mobile phone transmitter the signal cannot get to your window</td><td>1 mark
1 mark
1 mark</td></tr>
<tr><td></td><td>Total:</td><td>37 marks</td></tr>
</table>

P3c The electromagnetic spectrum

Page 164

1. Shine a ray of white light at an angle to one of the faces of the prism.
2. 3×10^8 m/s.
3. X-rays.
4. Gamma, UV, visible, infrared, microwaves

Page 167

1. Gamma rays are produced by radioactive nuclei. X-rays are produced by firing high energy electrons at a metal target.
2. By exciting the atoms in a mercury vapour.
3. An image of infrared radiation.
4. Water particles in food absorb microwave energy, by which they gain energy and get hotter.

Page 168 (top)

Students' own answers.

Page 168 (bottom)

Students' own answers.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	light	1 mark
1 b)	ultraviolet	1 mark

Question	Correct answer	Marks
1 c)	microwaves	1 mark
1 d)	X-rays	1 mark
1 e)	infrared	1 mark
2 a)	they can pass through soft tissue and kill cancer cells. Gamma rays are useful because of their great penetrating power this is also their disadvantage consequently they have to be used extremely carefully	1 mark 1 mark 1 mark
2 b)	they can damage healthy cells and cause cancer because of their very high energy	1 mark 1 mark 1 mark
2 c)	they have different frequencies and wavelengths	1 mark
2 d)	300 000 000 m/s	1 mark
3 a)	radio, microwaves, infrared, visible, ultraviolet, X-rays, gamma	4 marks
3 b)	the order would be reversed	1 mark
4	heat energy heats air surrounding heater causing convection current which then warms air around hands	1 mark 1 mark 1 mark
5	completed table as shown	13 marks

Wave type	**Source of wave**	**Use**	**Property**
Radio	Radio transmitter and aerial	**Communication**	**Low-energy waves**
X-rays	X-ray tubes	Security at airports	**Penetrate tissue**
Visible light	Lamps, Sun and flames	**Seeing**	Can be dispersed into seven colours
Ultraviolet	Mercury vapour lamps	Security markings	**Causes some chemicals to fluoresce**
Infrared	**All warm objects**	Thermal imaging	Can cause burns
Gamma	Radioactive substances	**Destroying cancer cells**	Very penetrating
Sound	**Vibrating objects**	Hearing	**Travels through solids, liquids and gases**
Microwaves	Magnetron	Heating food quickly	**Cause water molecules to vibrate**

Question	Correct answer	Marks
6	microwaves cause water molecules in food to vibrate more than in cold	1 mark

Question	Correct answer	Marks
	state raising internal energy of food and thus cooking it	 1 mark 1 mark
7	radio waves carry audio and visual information through distance to receiver where the information is converted back to audio and visual	1 mark 1 mark 1 mark
8	radio waves will be diffracted over the hill and be received at the house better than short wave television waves, so radio reception will be better	1 mark 1 mark 1 mark
	Total:	43 marks

P3d Light and sound

Developing investigative skills, page 177

1. For each pair of sighting pins, trace a line back from them through the line of the mirror and beyond. Where the two lines cross is the position of the image.

2. Trace a line from a pair of sighting pins back to the mirror. From the point this line reaches the mirror; draw a second line to the object pin. This traces the path of the light ray as it reflects off the mirror. Measuring the correct angles will confirm the law of reflection.

3. Check diagram against the diagram in the main text.

4. If the diagram is drawn accurately, these measurements will be correct.

5. The student should place a pin at the image position and observe the object pin in the mirror again. If the image pin is in the correct place, then no parallax will be observed between the image in the mirror and the object pin.

6. The method will have only limited success with curved mirrors since the image is sometimes real and sometimes virtual, depending on the location of the object pin. However, it will still allow the student to check the law of reflection.

Page 177

1. Virtual image, laterally inverted, same size and upright.

2. 48°.

3. The 'normal' is the imaginary line at 90° to a mirror.

4. A virtual image is an image that cannot be projected onto a screen.

Page 180 (top)

1. Slower.

2. Diamond, because its refractive index is greatest.

3. Air: 2.99×10^8 m/s; water: 2.25×10^8 m/s; glass: 1.97×10^8 m/s; diamond: 1.24×10^8 m/s.

Page 180 (bottom)

1. The light from a submerged object is refracted away from the normal as it leaves the pond, so it approaches your eye at a shallower angle. Your brain is fooled into thinking this shallower angle is the true angle to the object.

2. Being more dense than air, the carbon dioxide in the balloon will slow down the sound wave. This will tend to focus the sound together, like a lens. (A balloon filled with hydrogen will do the opposite).

3. 30.7°.

4. 36.3°.

5. 1.43.

Developing investigative skills, page 181

1. Standard diagram with surface indicated, normal line drawn in and angles of incidence and refraction correctly marked.

2. Draw along edge of block while it is in position. With the block removed, find the point where the light entered. At that point, use a protractor to mark in the line at right angles – this is the normal.

3. refractive index = sin *i* ÷ sin *r.*

4. Graph should be a straight line through the origin.

5. Refractive index = gradient of the graph.

6. Even though the ray of light is narrow it still has some width and this can make some of the measurements difficult. In particular, marking the path of the ray can be uncertain (possibly avoided by marking the edge of the ray) and it is difficult to the normal in exactly the correct position. Correctly drawing in the path inside the block is also difficult to do accurately.

7. A different colour of light would have a different wavelength. This would lead to a different change in speed of the light and so a different angle of refraction (think of how a prism disperses light). However, at the level of precision of this experiment it is unlike to have a significant effect on the final value calculated.

Page 185

1. The angle of incidence at which the angle of refraction becomes equal to 90°.

2. 45.6°.

3. By repeated internal reflection.

4. It always hits the surface at an angle greater than the critical angle.

5. Infrared rays.

6. In endoscopes.

Page 187

1. A signal that can have any value over a range. Graph should look like left-hand part of Fig. 3.44.

2. A signal that can only have the value 0 or 1 – it is a series of numbers. Graph should look like right-hand part of Fig. 3.44.

3. Much less information is lost during transmission.

4. They have to be converted back to analogue signals.

5. The information is not lost in transmission – the detector only has to decide if the signal is on or off.

Page 189

1. Longitudinal waves.

2. Small differences in air pressure.

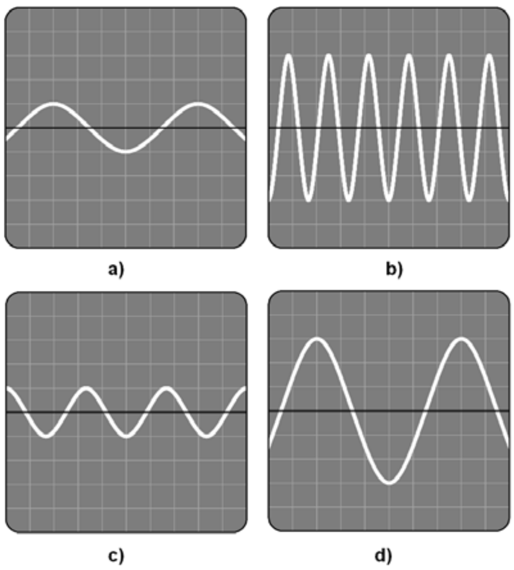
3. 20 – 20 000 Hz.

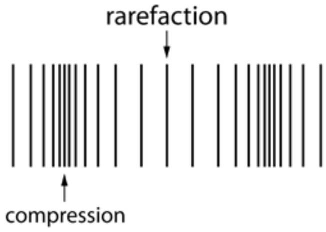
4. Ultrasound is sound above range for human hearing.

5. Method should have the features of the Developing Investigative Skills box on measuring the speed of sound.

End of Topic Questions mark scheme

1 a)	in reflection light changes direction when it bounces off a surface. In refraction the light changes direction when it passes from one medium to another OR in refraction the angle of incidence does not equal the angle of refraction, as the ray of light bends towards or away from the normal	1 mark
1 b) i)	diagram completed showing ray 1 going straight through, ray 2 refracted towards normal at first boundary and away from normal at second	1 mark
1 b) ii)	angle of incidence	1 mark
1 b) iii)	normal line	1 mark
2 a)	you should draw a normal line to ensure that for each reflection the angles of incidence and reflection are the same	1 mark
2 b)	one of: binoculars, bicycle reflector, cat's eyes, periscope	1 mark
2 c) i)	reflection	1 mark
2 c) ii)	total internal reflection and reflection	1 mark
2 c) iii)	total internal reflection	1 mark
3 a)	refractive index = sin 50° ÷ sin 21.7° = 2.07	1 mark 1 mark
3 b)	sin r = sin 90° ÷ 2.07 = 28.9°	1 mark 1 mark
4 a)	vibrations	1 mark
4 b)	compressions and rarefactions travel through the air in the direction the wave is travelling	1 mark 1 mark 1 mark
4 c)	sound waves cannot travel through a vacuum radio waves do not require a medium so they can travel through a vacuum	1 mark 1 mark 1 mark
4 d)	the lower frequency sound can bend round the buildings and other obstacles between you air absorbs high frequencies quite strongly as they travel through it bass notes are not absorbed as much	1 mark 1 mark 1 mark
5	150 ÷ 0.44	1 mark

	341 (or 340) m/s	1 mark 1 mark
6	85 m	1 mark
7	the different densities of the hotter and cooler parts of the air cause the light to change direction as it passes through so when the light reaches you it has the ‘shimmering’ effect as some light arrives slight out of sequence from what you would expect	1 mark 1 mark 1 mark
8	if the fibre is too wide, there are too many paths available to the light and so a pulse that starts as a ‘sharp’ pulse can become stretched out into a ‘smudge’ as the light following longer and shorter paths takes different times to get through the fibre	1 mark 1 mark 1 mark
9	at 44 kHz (approximately two times the highest frequency humans can hear) the sampling picks up enough detail in the sound wave so that, when played back, we cannot tell there is any detail missing	1 mark 1 mark 1 mark
10	ultrasound, like any sound, is a mechanical vibration transferring energy it is this energy that can be used to knock dirt from watches and jewellery they are likely to be in water so the energy transfer is even more efficient	1 mark 1 mark 1 mark
11	digital signals are better quality because they do not have so much interference from other signals, and the strength of the signal can be 'boosted' without losing information	1 mark 1 mark
12	optical fibres have a high transparency – they don't absorb much of the light signal passing down them	1 mark 1 mark
13	different wavelengths would be refracted different amounts so the signal would be split up	1 mark 1 mark
14		4 marks (1 mark for each)

15 a) i)	the prongs of the tuning fork move back and forth	1 mark
15 a) ii)	when the prongs move towards each other, the air is compressed between the prongs creating a compression, while a rarefaction occurs on the outside of the prongs	1 mark
15 a) iii)		1 mark
15 b)	when the tuning fork prongs are dipped into water ripples can be seen travelling out from the prongs	1 mark 1 mark
16 a)	refracted ray towards normal at first boundary then away from normal at second	1 mark
16 b)	emergent ray at second glass/air boundary	1 mark
16 c)	normal at 90 degrees to boundary (i.e. horizontal)	1 mark
16 d)	depends on students' diagram	1 mark
16 e)	light refracted when it enters a medium of different density to previous	1 mark
17 a)	$650 \times 10^{-9}/1.44$ $= 451 \times 10^{-9}$ m	1 mark 1 mark
17 b)	shorter wavelength than red so towards violet end of spectrum	1 mark 1 mark
17 c)	6 .65 × 10^{14} Hz	1 mark
	Total:	65 marks

Section 3: Answers to exam-style questions

Question	**Correct answer**	**Marks**
2 a) i)	A	1 mark
2 a) ii)	C	1 mark
2 b) i)	suitable example, for example, light	1 mark
2 b) ii)	transverse – vibration is perpendicular to direction of energy transfer	1 mark 1 mark
2 c) i)	6 ÷ 10	1 mark
2 c) ii)	1.7 (Hz)	1 mark
2 c) iii)	speed = frequency × wavelength	1 mark
2 c) iv)	1.7 × 0.05 0.085 (m/s)	1 mark 1 mark
3 a)	NOTE – any suitable method allowed (for example, raybox or sighting pins) suitable equipment	 2 marks

	how to carry out measurements plot graph of sin *i* against sin *r*	3 marks 1 mark
3 b)	total internal reflection (named) describe two conditions for law of reflection can bend fibre	1 mark 2 marks 1 mark 1 mark
	Total:	21 marks

Section 4 Energy resources and energy transfer

P4b Energy

Page 207

1. Gravitational – kinetic – gravitational.
2. In springs.
3. Bonds between atoms.
4. Light energy to electrical energy.

Page 208

1. Energy cannot be created or destroyed.
2. Electrical energy is transferred to light and heat energy.
3. a) Electrical energy.
   b) Kinetic energy.
   c) Heat, sound and light energy.

Developing investigative skills pages 210–211

1. Mass – balance. Length – (metre) ruler. Time – stopclock/stopwatch. Potential difference – voltmeter. Current – ammeter.
2. Since the timing involved starting and stopping the clock, the student probably decided that reaction time would make a difference, that is, recording times to 0.01 s was not realistic for hand timing. Could argue that to record to nearest 0.1 s is still quite ambitious.
3. Table completed correctly for values given.
4. Graph plotted correctly for data calculated.
5. Suitable sentence or two that correctly describes the pattern in the data.
6. Need to realize that the gradient of the line is equal to the efficiency.
7. Sensible comment required – could suggest extending the range, for example, to 0.11 kg to see if the pattern continues, or could suggest testing intermediate values, for example, 0.04 kg, to add detail within the range already tested.

Page 213 (top)

Student's own Sankey diagrams.

Page 213-214

1. How much energy is transferred each way.
2. Sankey diagram should have 1000 J as input. There should be two output arrows, one labelled 400 J useful heat energy, the other 600 J waster heat energy. The sizes of the arrows should be in proportion.
3. 40%.
4. a) 39 200 J.
   b) 2%.

Page 215 (top)

Use petroleum jelly to attach drawing pins at regular distances along the copper strip. Heat one end of the strip and measure the time it takes for each drawing pin to fall off. Plot a graph of time until the drawing pin falls off against distance from the point that is being heated.

Page 215 (bottom)

1. They contain electrons that can move freely and transfer energy.

2. There are no particles to transfer energy by colliding with each other.

3. Vibrations of the particles are passed on through the bonds between the particles.

4. Some wax is put on one end of a metal rod. The other end of the metal rod is heated until the wax on the other end melts.

Page 216

1. The particles are free to move.

2. Warm air expands, which makes it less dense. Less dense air floats up above more dense (cooler) air.

3. Heat some potassium manganate(VII) crystals in water.

4. Fibres in the insulation create air pockets. This restricts the movement of the air and so convection currents cannot form.

Page 218

1. It can travel through a vacuum.

2. A hot object.

3. Temperature and type of surface.

4. The dull, black side.

Developing investigative skills, page 220

1. So that you know what is the lowest temperature the water will cool to.

2. Every 3 minutes.

3 a) Same shape, more points

b) Fewer points, shape curve may not be as obvious.

4. By insulating the beaker

5. Record the cooling curve for different starting temperatures.

Page 220 (bottom)

1. Convection.

2. The top of the room.

3. a) Conduction – reduced by having a vacuum (no particles to connect).

b) Convection – vacuum space has no particles to form convection currents.

c) Radiation – silver surfaces reflect the energy and do not absorb or emit it.

4. The flask reduces energy transfer in both directions, so hot drinks do not lose their energy and cold drinks are not warmed by energy entering from outside.

Page 222

1. More than half the energy wasted is through these two features.

2. Answer should refer to trapped air in the walls, roof, windows, etc.

3. Air is a bad conductor (good insulator) so keeping a layer near the body reduces heat loss by conduction. Keeping the layer trapped reduces heat loss by convection.

4. In hotter climates, you may want to lose heat, so loose clothing allows the air to move and transfer heat away.

End of Topic Questions mark scheme

<table>
<tr><th>Question</th><th>Correct answer</th><th>Marks</th></tr>
<tr><td>1</td><td>the thin layers will trap air between them
air is an insulator
and so will reduce thermal transfer from the body</td><td>1 mark
1 mark
1 mark</td></tr>
<tr><td>2</td><td>energy from the hot water
is transferred from the inner to the outer surface of the metal by conduction
energy is transferred through the still air by radiation</td><td>1 mark
1 mark
1 mark</td></tr>
<tr><td>3 a)</td><td>3500
J</td><td>1 mark
1 mark</td></tr>
<tr><td>3 b)</td><td>70%</td><td>2 marks</td></tr>
<tr><td>4 a)</td><td>20
J</td><td>1 mark
1 mark</td></tr>
<tr><td>4 b)</td><td>40%</td><td>2 marks</td></tr>
<tr><td>5</td><td>completed table as shown
<table>
<tr><th>Object</th><th>Input energy</th><th>Useful energy</th><th>Wasted energy as heat</th><th>Efficiency</th></tr>
<tr><td>Light bulb</td><td>100 J</td><td>10 J</td><td>90 J</td><td>10%</td></tr>
<tr><td>Torch</td><td>70 J</td><td>55 J</td><td>15 J</td><td>79%</td></tr>
<tr><td>Radio</td><td>250 J</td><td>210 J</td><td>40 J</td><td>84%</td></tr>
</table></td><td>12 marks</td></tr>
<tr><td>6</td><td>liquids and gases become less
dense
when heated</td><td>1 mark
1 mark
1 mark</td></tr>
<tr><td>7</td><td>the particles in a solid are fixed in position
so vibrations pass readily
from particle to particle</td><td>1 mark
1 mark
1 mark</td></tr>
<tr><td>8</td><td>air above the convection heat absorbs energy
becomes less dense and rises, being replaced by cooler air
which in turn is warmed and rises. So a convection current transfers energy from the convection heater around the room</td><td>1 mark
1 mark
1 mark</td></tr>
<tr><td>9</td><td>serving dishes are made of insulators</td><td>1 mark</td></tr>
</table>

	so that they do not transfer energy away from (or into) the food this keeps hot food hot (or cold food cold) and makes it less likely that someone handling the dish will be burned	1 mark 1 mark
10	any three of the following: the material the object is made from the volume and surface area of the object the appearance of the surface (light, dark, dull, shiny) the temperature difference between the object and the surroundings	3 marks (1 mark for each)
11	the useful energy output arrow for the Sankey diagram should be ¼ the width of the input energy arrow	1 mark 1 mark 1 mark
12	lubricants improve the efficiency of an engine because they reduce friction so reduce the amount of energy 'wasted' by being transferred as heat to the surroundings as work is done to overcome frictional forces	1 mark 1 mark
13	65%	2 marks
14	280 J	1 mark 1 mark
15	480 J	1 mark 1 mark
16	9.8 J	1 mark 1 mark
17	petrol engine 30% efficiency steam-diesel hybrid 25% petrol engine is more efficient	1 mark 1 mark 1 mark
	Total:	57 marks

P4c Work and power

Page 228 (top)

1. $8.45 \times 10^{12}/8 \times 10^{3}$ N = 1.06×10^{9} N.

2. Series of manoeuvres used before landing to get rid of excess energy.

3. 1650 °C. The orbiter is covered with ceramic insulating materials designed to protect it from this heat. The materials include:
Reinforced carbon-carbon (RCC) on the wing surfaces and underside
High-temperature black surface insulation tiles on the upper forward fuselage and around the windows
White Nomex blankets on the upper payload bay doors, portions of the upper wing and mid/aft fuselage
Low-temperature white surface tiles on the remaining areas

Page 228 (bottom)

1. 250 J

2. 500 N

3. 80 J

4. 50 m

5. 400 N

Page 230

Student's own answers, but should include key points from the text.

Page 231 (top)

A suitable argument backed up by calculations. For example, a 16 lb ball bowled at 6.5 m/s will have kinetic energy of 153 J. A 10 lb ball bowled at 10 m/s will have kinetic energy of 227 J. As kinetic energy increases in proportion to the square of speed, but is a linear relationship with regard to mass, Rageh is more likely to be correct if you can throw a lighter ball faster.

Page 231 (bottom)

1. 100 J

2. 4 J

3. 812.5 J

4. 8 kg

5. 3 m/s

Page 233

1. 100% efficiency.

2. Heat energy from friction.

3. 8.9 m/s.

Page 236

Student's own work. One line has been filled in as an example.

Activity	Mass (kg)	Height (m)	Energy (J) (mass × height × 10)	Time taken (s)	Power (W) (energy/time)
lifting tin of food from floor to head height	0.4	2.4	9.6 J	1 s	9.6 W

Page 237

1. 240 W.

2. The man lifts twice the mass up the stairs, so he does twice the work. They take the same time, so the man must be providing twice the power.

3. It can transfer a lot of energy each second.

4. The watt.

5. a) 3 000 J.

   b) 50 W.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	12.5 m	1 mark 1 mark
2 a)	energy transferred = 90 J (per step) × 200 (number of steps) = 18 000 J	1 mark 1 mark
2 b)	power = energy transferred/time taken = 18 000/180 = 100 W	1 mark 1 mark
3 a)	10 500 J	1 mark 1 mark
3 b)	24.5 m/s	1 mark 1 mark
3 c)	Some of the gravitational potential energy will have been transferred to thermal energy due to the friction between the sledge and the snow.	1 mark 1 mark 1 mark
4	Row 1: 200 (J) Row 2: 2 (N) Row 3: 75 (m) Row 4: 90 000 (J) Row 5: 100 (N) Row 6: 400 (m)	1 mark 1 mark 1 mark 1 mark 1 mark 1 mark
5	27 000 J	1 mark 1 mark
6	4 m	1 mark 1 mark
7	90 m	1 mark 1 mark
8	Row 1: 3442.5 (J) Row 2: 200 (kg) Row 3: 8 (m/s) Row 4: 80 275 (J) Row 5: 3 (kg) Row 6: 0.71 (m/s)	1 mark 1 mark 1 mark 1 mark 1 mark 1 mark
9	3.6 J	1 mark 1 mark
10	0.77 m/s	1 mark 1 mark
11 a)	30	1 mark

	J	1 mark
11 b)	1890 J	1 mark 1 mark
11 c)	1920 J	1 mark 1 mark
11 d)	At bottom of slope total KE = 1920 J KE = ½ mv^2 1920 = ½ × 60 × v^2 v^2 = 1920 ÷ 30 = 64 $v = \sqrt{64}$ = 8 m/s	1 mark 1 mark 1 mark
	Total:	44 marks

P4d Energy resources and power generation

Developing investigative skills, page 243

1. Students' own ideas.
2. Students' own table.
3. Students' own ideas.

Page 244

Student's own answers.

Page 248

1. Light energy to electrical energy and heat energy.
2. Kinetic energy in wind to kinetic energy in turbine to electrical energy and heat energy.
3. A fuel is used to turn water into steam. The steam has kinetic and thermal energy and drives a turbine. The turbine drives a generator which transfers the kinetic energy to electrical energy.
4. Using heat energy from the Earth.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	a source that cannot be regenerated – it takes millions of years to form	1 mark 1 mark
1 b)	coal, oil and natural gas	1 mark 1 mark 1 mark
1 c)	coal it is estimated that there is about 300 years' supply	1 mark 1 mark
2 a)	the total energy used over this period has increased there was a reduction in energy used from 1980 to 1983,	1 mark 1 mark

	but since then the consumption has increased	1 mark
2 b)	the use of oil reduced up until about 1985, but has remained fairly constant since then. The use of coal has reduced as the use of natural gas and nuclear power has increased	1 mark 1 mark 1 mark
2 c)	I would expect energy consumption to continue to increase I would expect the use of renewable energy sources to increase, the use of coal to decrease	1 mark 1 mark 1 mark
3 a)	any two from: strength of the wind high ground constant supply of wind open ground	2 marks
3 b)	advantage: renewable energy source, no air pollution disadvantage: unsightly, takes up too much space	1 mark 1 mark
4	renewable resources advantages: wind power and solar power are very efficient hydroelectric power can be used to store energy disadvantages: wind power only works when the wind is blowing solar power only works during the day non-renewable resources advantage: can be built close to population centres disadvantage: one of: fuel supplies will run out efficiency is only about 40%	 1 mark 1 mark 1 mark 1 mark 1 mark 1 mark
5 a)	the wind does not always blow sometimes it blows but not hard enough to generate electricity at other times it can be blowing too hard and the turbine has to be shut down	1 mark 1 mark 1 mark
5 b)	no need to transport fuel to the area no need for expensive power cables to transmit the power to the area	1 mark 1 mark 1 mark
6 a)	coal oil natural gas	1 mark 1 mark 1 mark
6 b)	advantage: close to population centres disadvantage: polluting	1 mark 1 mark
7 a)	coal	2 mark
7 b)	coal	2 mark
8	transport links	1 mark

	size of site ease of link to national grid	1 mark 1 mark
9 a)	cost of running cost of building the power station	1 mark 1 mark
9 b)	oil increase hydroelectric stay same	1 mark 1 mark
9 c)	transferred to electrical energy some wasted as heat energy	1 mark 1 mark
9 d)	hydroelectric	2 mark
9 e)	coal: advantage – can be sited near population, disadvantage – polluting hydroelectric: advantage – renewable, disadvantage – requires large area to be flooded for reservoir	1 mark 1 mark
10	students' own report	5 marks
	Total:	59 marks

Section 4: Answers to exam-style questions

Question	Correct answer	Marks
2 a) i)	current = 3 A voltage = 12 V	1 mark 1 mark
2 a) ii)	12 × 3 × 600 21 600 (J)	1 mark 1 mark
2 b) i)	efficiency = useful energy out ÷ total energy in	1 mark
2 b) ii)	18500 ÷ 21600 0.86/86%	1 mark 1 mark
2 b) iii)	energy transferred to surroundings	1 mark 1 mark
2 c) i)	electrical heat/thermal heat/thermal surroundings	1 mark 1 mark 1 mark 1 mark
2 c) ii)	students' own Sankey diagram	3 marks
3 a) i)	GPE = mass × g × height	1 mark
3 a) ii)	30 × 10 × 3 900 (J)	1 mark 1 mark
3 a) iii)	equal	1 mark
3 a) iv)	time taken	1 mark
3 b)	KE gained = GPE lost equation for KE	1 mark 1 mark

	correct substitution correct value	1 mark 1 mark
	Total:	25 marks

Section 5: Solids, liquids and gases

P5b Density and pressure

Page 261

1.a) 40 cm^3

b) 7.8 g/cm^3

2. The bread contains more air spaces, making the overall density less.

3. It is lower than the density of water.

Page 264-265

1. When the object floats, absorbs the liquid (like a sponge) or is damaged by it (such as dissolving).

2. Narrow as possible to give greater movement of level, fine scale to help with precision.

3. 1.2 g/cm^3

4. 78 g

5. 7.14 cm^3

Developing investigative skills, page 265

1. Measure the length of each side (in different places to check if shape really is regular) and then multiply length × width × height.

2. Checking the zero improves the accuracy – it makes it more likely that the mass value recorded Is the correct value.

3. With the values given, the most sensible unit is g/cm^3, but could convert to metres and kilograms. The values are aluminium 2.7 g/cm^3, brass 8.4 g/cm^3, copper 8.9 g/cm^3, iron 7.9 g/cm^3

4. Two significant figures is appropriate, since the volume is only given to a precision of two significant figures.

5. For an irregular object, the mass can still be found using a balance. However, the volume now needs a different method. Typically this will involve displacing water, either in a measuring cylinder or a eureka can, and finding the volume of the water displaced when the object is inserted. This method will not work if the object is soluble or absorbs water.

Page 267

1. For the pin, the force is concentrated over a smaller area – there is a greater pressure.

2. 500 Pa

3. 80 N

4. 0.78 m^2

Developing investigative skills, page 269

1. Pressure = force ÷ area so different pressures can be achieved by changing either the force (by adding more 100 g masses), the area (by standing the block on different faces) or both.

2. Can be quite difficult to do reliably, but would need to have some way to level the surface (e.g. scrape with a rule) and some way to estimate depth – possibly by having a scale attached to the block. Would need to measure in several points around the block to find an average depth.

3. Independent variable is the pressure, dependent variable is the depth the block sinks.

4. Sand is a solid, even though it is made of quite small particles. As the block pushes down, there is little space between the grains of sand and they cannot be compressed. So if the downwards pressure on the block is high enough, the only thing the sand can do is move out to the side, making it more difficult to find the average depth of sinking.

5. Need a way to measure how much water has been added. Particularly helpful to have a container with no drainage holes at the bottom, then you know that all the water is in there somewhere. Use a measuring cylinder to add a known volume of water to the sand and carry out the test.

6. A camel's foot is an example of a load being spread over a wider area to reduce the pressure.

Page 270

1. Particles colliding with other particles and the walls of the container.
2. The same air pressure is in our lungs and presses outwards.
3. The pressure outside the bottle is greater than the pressure inside the bottle.

Page 273

1. Depth, density of the fluid, gravitational field strength.
2. 80 000 Pa (80 kPa).
3. 1 030 000 Pa (1030 kPa).
4. 400 kPa.
5. 20 400 Pa (20.4 kPa).

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	depends on the sample	1 mark
1 b)	float	1 mark
1 c)	depends on the sample	1 mark
1 d)	float	1 mark
1 e)	sink	1 mark
1 f)	sink	1 mark
1 g)	float	1 mark
2	1900 kg/m^3	1 mark
3	if the crown is pure gold, the new water level will be 900 cm^3 if the jeweller has cheated, the water level will be higher than 900 cm^3	1 mark 1 mark 1 mark 1 mark
4 a) i)	160 kPa	1 mark 1 mark
4 a) ii)	159 kPa	1 mark 1 mark
4 a) iii)	8000 kPa	1 mark 1 mark

4 b)	the high-heeled shoe will damage the floor	1 mark
5 a)	he is 15 m deep	1 mark 1 mark
5 b)	the submarine would be slightly less than 15 m deep	1 mark
6 a)	29.4 kPa	1 mark
6 b)	189.4 kPa	1 mark
7	7.2×10^5 Pa	1 mark 1 mark
8	1.44×10^7 Pa	1 mark 1 mark
9	$(2.96 \times 10^5 – 1.00 \times 10^5) \div (1000 \times 10)$ = 19.6 m	1 mark 1 mark 1 mark
10	7.2×10^{-3} kg	1 mark 1 mark
11 a)	$p = \rho g h$ (pressure = density × acceleration due to gravity × depth)	2 marks
11 b)	5000 Pa	1 mark 1 mark
12	1750 m	1 mark 1 mark
13	2.23×10^5 Pa	1 mark 1 mark
14	1.07×10^5 Pa	1 mark 1 mark
	Total:	43 marks

P5c Changes of state

Page 279

1. Increases – either as a larger vibration in solids or as faster translational motion in liquids and gases.

2. Compressing a gas pushes the particles closer together, in a liquid they are already close to each other and will repel if pushed closer.

3.a) Regular pattern, closely packed together, particles held in place.

b) Irregular, closely packed together, particles able to move past each other.

c) Irregular, widely spaced, particles able to move freely.

4. The size of the container it is put in.

Page 281

Student's own answers, but should be along the following lines.

1. I changed from liquid state to gaseous state.

2. In the liquid state I was reasonably close to my neighbours, but not so close that I was right beside them – they were there if I needed them but we didn't live in each other's pockets! I was given some extra energy.

3. The extra energy meant that I moved more quickly and was able to break completely away from my neighbours. I escaped to the surface of the liquid and became a gas particle.

Page 282

1. Energy is needed to break the bonds between the particles in the ice.

2. All the particles have the energy to escape. In evaporation, only a fraction has.

3. A special liquid evaporates inside tubes inside the refrigerator. The vapour is collected and compressed back into a liquid in a compressor behind the refrigerator. It is then evaporated again.

4. Higher temperature, flow of air across the surface.

5. Larger area for the water molecules to evaporate from.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	solids keep their shape because their particles are closely packed together and are held in a rigid shape by the bonds between the particles,	1 mark
	whereas the particles in liquids and gases are able to move	1 mark
1 b)	gases fill their container because their particles move about freely,	1 mark
	whereas the particles in a solid vibrate within their structure and those in a liquid only slide over each other	1 mark
2	evaporation	1 mark
3 a)	dish A shows least evaporation,	1 mark
	dish B shows more evaporation, and dish C shows most evaporation	1 mark
3 b)	in dish A, some of the molecules in the water that have high K.E. manage to escape from the surface of the water	1 mark
	in dish B the dish absorbs infrared radiation from the Sun and warms the water. When the temperature of the water increases, the number of water molecules with high KE increases and more of them evaporate	1 mark
	in dish C, the just-evaporated water molecules are swept away by the wind and are less likely to return into the water	1 mark
3 c)	while the water is evaporating,	1 mark
	much of the energy absorbed by the dish is carried away by the water molecules with high KE	1 mark
	when the water has evaporated, this route for the heat energy to escape is blocked and so the heat energy is used to raise the temperature of the dish	1 mark
4	during evaporation, only a few particles have enough energy to escape from the liquid state to the gas state	1 mark

Question	Correct answer	Marks
	in boiling, all the particles have sufficient energy to escape	1 mark 1 mark
5	in a solid the particles are in fixed positions the particles gain energy and the bonds between them are broken they gain enough energy so that they can move freely in a liquid	1 mark 1 mark 1 mark
6	the molecules in the gel gain energy from your hand some molecules evaporate taking the energy with them there is less energy left in the gel and so it feels colder	1 mark 1 mark 1 mark
7	the windows are cold the water vapour molecules collide with the window the window absorbs their energy and they stay as a liquid	1 mark 1 mark 1 mark
8	liquid B will evaporate more easily because less energy has to be absorbed to break the bonds in liquid B	1 mark 1 mark 1 mark
9	hairdryer uses heat energy which makes the water evaporate from your hair also it uses moving air to carry the water vapour away, so that more water can easily leave your hair	1 mark 1 mark 1 mark
10	it is more likely to rain, as water is more likely to condense as it gets cooler, because the particles have less energy	1 mark 1 mark 1 mark
11	as the gas condenses, its particles have less energy the energy they did have is transferred to the surroundings making the surroundings warmer	1 mark 1 mark 1 mark
12	lower air pressure means less force pushing down on the surface of a liquid this means a liquid particle needs less energy in order to escape from the surface, so the liquid will evaporate more quickly	1 mark 1 mark 1 mark
	Total:	40 marks

P5d Ideal gas molecules

Page 287

1. The molecules are always moving about and spread out throughout the container.

2. If the pressure of the gas stays constant, then the volume of the gas is proportional to its absolute temperature.

3. A higher temperature means the molecules move more quickly, so the force on the walls will be higher. If the pressure stays constant and the force is higher, then the volume must increase to give a larger surface area for the molecules to collide with.

4. The mass of the gas must remain constant (that is, no particles move in or out of the system). The temperature must be measured using the Kelvin scale. The gas must be ideal (not liquefy or solidify).

Page 288

1. The random motion of small particles in a gas or liquid.

2. The small particles we can see are being hit by even smaller particles that we cannot see.

3. The particles are colliding with the walls of the container.

4. Faster molecules hit the walls harder, so create a bigger force.

Page 289

1. a) 323 K

   b) 2273 K

2. a) –173 °C

   b) 1227 °C

3. They stop moving/vibrating.

Page 291

1. The temperature is proportional to the average kinetic energy, as long as the temperature is measured in Kelvin.

2. Any relevant units can be used for pressure, as long as the same units are used throughout.

3. a) 289 K

   b) 318 kPa.

Page 293

1. The pressure is inversely proportional to volume.

2. The temperature must remain constant (as well as the mass of gas in the container).

3. 519.8 cm^3.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	as temperature increases, speed increases	1 mark
	– it is NOT a proportional link. (If the Kelvin scale of temperature is used, then the average *kinetic energy* of the molecules is proportional to the temperature.)	1 mark
2	the molecules, in random motion, hit the container walls	1 mark
	this causes a force to act on the walls (look back to ideas included in Newton's second law) and pressure = force/area	1 mark
3	it is the lowest possible temperature,	1 mark
	the temperature where the molecules would have zero kinetic energy (and zero speed)	1 mark

Question	Correct answer	Marks
4 a) i)	293 K	1 mark
4 a) ii)	423 K	1 mark
4 a) iii)	1273 K	1 mark
4 b) i)	27 °C	1 mark
4 b) ii)	377 °C	1 mark
4 b) iii)	727 °C	1 mark
5	$V_2 = V_1T_2/T_1$ = (1500 × 260)/293 = 1330 cm^3	1 mark 1 mark 1 mark
6	$p_2 = p_1V_1/V_2 = 10^5 \times 20/5$ $= 4 \times 10^5$ Pa	1 mark 1 mark 1 mark
7	$p_2 = p_1T_2/T_1 = 5 \times 10^5 \times 325 \div 290$ $= 5.6 \times 10^5$ Pa	1 mark 1 mark 1 mark
8	$V_2 = p_1V_1/p_2 = 1.5 \times 10^5 \times 5 \times 10^{-3} \div 1 \times 10^5$ = 0.075 (or 7.5×10^{-3}) m^3	1 mark 1 mark 1 mark
9	$T_2 = p_2T_1/p_1 = 5 \times 10^6 \times 290 \div 2.5 \times 10^6$ = 580 K	1 mark 1 mark 1 mark
10 a) i)	1.08 m^3	1 mark 1 mark
10 a) ii)	0.91 m^3	1 mark 1 mark
10 a) iii)	910 minutes	1 mark 1 mark
10 b)	$T_2 = p_2T_1/p_1 = 1 \times 10^6 \times 280 \div 9.5 \times 10^5$ = 295 K	1 mark 1 mark 1 mark
	Total:	36 marks

Section 5: Answers to exam-style questions

Question	Correct answer	Marks
2 a)	density = mass ÷ volume	1 mark
2 b) i)	need small scale divisions	1 mark

	so use ruler marked in mm	1 mark
2 b) ii)	difficult to mould clay to uniform shape	1 mark 1 mark
2 c)	put water to known level in measuring cylinder submerge clay in water measure new water level difference gives volume of clay	1 mark 1 mark 1 mark 1 mark
2 d) i)	set balance to zero and place on it	1 mark
2 d) ii)	will be inaccurate	1 mark
2 d) iii)	compare with known mass/balance that is known to be correct	1 mark 1 mark
3 a) i)	suitable scales plotting line if drawn/comment otherwise	2 marks 2 marks 1 mark
3 a) ii)	reasonable comment, e.g. lower values tend to be a little lower but not clear pattern OR pattern inconsistent so cannot state this conclusion	2 marks
3 b)	student incorrect rate of cooling changes at different temperatures so starting difference will alter temperature change	1 mark 1 mark 1 mark
3 c) i)	valid results allow you to answer the original question	1 mark
3 c) ii)	with no lid convection can happen (easily) much more significant than conduction (through walls) so not testing the original question	1 mark 1 mark 1 mark 1 mark
	Total	28 marks

Section 6: Magnetism and electromagnetism

P6b Magnetism

Page 306

1. They attract each other.

2. They repel each other.

3. It will line up approximately north–south.

Page 307

1. Magnetically hard materials retain their magnetism; magnetically soft materials lose their magnetism if the outside magnetic influence is removed.

2. An alloy is a material composed of a mixture of metals. A ferrous material contains a significant proportion of iron.

3. A permanent magnet that is made of magnetically hard materials.

4. In electromagnets and relays.

Page 310 (top)

1. A region of space where their magnetism affects other objects.

2. The path that a free north pole would take from a north pole to a south pole.

3. Using iron filings on a thin sheet of plastic or a plotting compass.

Page 310 (bottom)

1. It has magnetism induced in it and is attracted to the magnet.

2. A south pole.

3. Attraction only tells you the material is a magnetic material. Only two magnets can repel, so that is the test.

4. Two north poles together or two south poles together.

Page 313 (top)

1. The magnetic field lines radiate out from the north pole and go round to the south pole.

2. They attract each other and the field lines go from a north pole to a south pole.

3. The field lines go from a north pole to a south pole, not between like poles.

Page 313 (bottom)

1. Magnetic field lines show the direction of a force (on a free north pole); if field lines crossed it would indicate a force in more than one direction, which makes no sense.

2. Even, the same strength at all places, etc.

3. Between the poles of a U-shaped magnet, or when opposite poles of two magnets are placed close to each other.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	a magnetically hard material stays magnetic once it has been magnetised	1 mark
	example: steel	1 mark
	a magnetically soft material does not stay magnetic when the source of magnetisation is removed	1 mark
	example: pure iron	1 mark
2	the piece of metal could just be made of a soft magnetic material	1 mark
	this will be attracted if it is brought near to a magnet	1 mark
	Ranjit could turn the piece of metal around and see if it is still attracted (in which case it is not a magnet) or repelled (in which case it is a magnet)	1 mark
3	see page 311 for the magnetic field pattern for a single bar magnet	1 mark
	if the magnet were made stronger, the field pattern would not change, but it is common to indicate the increased field strength by drawing more lines between the original ones	1 mark
4	place the bar magnets under a sheet of paper	1 mark
	sprinkle iron filings on top of the paper	1 mark
	the iron filings will show the field pattern of each magnet	1 mark
	and the pattern between the magnets	1 mark
5	take two magnets of equal strength	1 mark
	place them with opposite poles facing each other	1 mark
	the magnetic field between the poles will be uniform	1 mark
	the same effect can be seen between the poles of a horseshoe magnet	1 mark
	Total:	17 marks

P6c Electromagnetism

Page 317

1. Make the wire into a coil. Connect one terminal of the battery to the switch and one end of the coil of wire. Connect the other end of the coil to the switch. Connect the switch to the other terminal of the battery.

2. Increase the current, increase the number of turns on the coil.

3. Diagram should be similar to Fig. 6.13.

Developing investigative skills, page 318

1. To vary the current, the student can place a variable resistor in series with the coil and the power supply. Different settings on the variable resistor will allow different currents in the circuit. The power supply the student uses may have a variable setting to do this. The student will need to include an ammeter in the circuit to measure the current.

2. The student should keep the number of turns on the coil constant (including keeping the spacing of the turns constant). Clearly the student should use the same nail throughout as different nails may have different diameters, etc. They should also keep the temperature of the coil constant (see question 7).

3. Line graph or bar chart. The current is a continuous variable, indicating that a line graph would be appropriate. However, the discrete nature of the paper clips measurement suggests that a best fit line may not be entirely suitable in this context.

4. As the current increases, the electromagnet can generally hold more paper clips. The ‘strength’ of the electromagnet is not a variable on the graph, so really should not be included in a statement of ‘what the graph shows’.

5. a) Hanging the paper clips in a bunch has the advantage of attaching quite a large number of paper clips, so in effect smaller variations in strength can be noted. However, it is not a particularly repeatable method since there are many angles that the clips can attach in and the student would have to judge how far up the nail to allow the paper clips to go.

   b) Hanging the clips in a line attached to each other is really testing the strength of the electromagnet at its tip since the other paper clips are really just adding extra weight. This method is not a particularly fine discriminator, since it will only pick up changes in terms of ‘whole paper clips’. Since the paper clips are attached, they could all be attached to the first on which should be connected to the tip of the electromagnet through magnetic attraction alone. For (c) the method really tests how well the magnet induces magnetism in the first paper clip and, consequently, how each paper clip in turn induces magnetism in the next. This method will work well if the paper clips are small so that finer adjustments can be made.

6. Still using paper clips, the measurements will be more precise if smaller paper clips are used, since this will allow smaller changes in the magnetic field to be noted. If a different measuring technique is used, such as measuring the repulsion between the electromagnet and a bar magnet resting on an electronic balance (where the repulsion gives an increased reading on the balance scale) then improved precision can be achieved.

7. As the current increases the heating effect in the coil will increase. With the plastic-coated wire typically used in school science labs this can result in the plastic melting, making the coil difficult to use. Also, the low voltage power supply used may have a cut out to prevent large currents being drawn from it.

Page 320

1. Sketch should match Fig. 6.19. Similar shape to bar magnet pattern – ‘fanning out’ at the poles; ‘loops’ along the sides, etc.

2. The field at the centre of the coil is most nearly uniform.

3. a) Sketch should match right-hand part of Fig. 6.17.

   b) Sketch should match left-hand part of Fig. 6.17.

Page 323

1. The current in the coil creates a magnetic field around it. This interacts with the magnetic field from the permanent magnet, producing forces in opposite directions on either side of the coil. Putting the coil on an axle allows these forces to spin the coil.

2. The commutator reverses the direction of the current in the coil each half-turn. This allows the coil to keep turning in the same direction.

3. Connect a length of wire across a power supply and coiled around one pole of a permanent magnet. Switch the current on and the wire jumps off the magnet.

4. The changing current in the coil produces a changing magnetic field which interacts with the field from the permanent magnet. This creates a ‘backwards and forwards’ motion of the coil and paper cone. This makes the air vibrate – a sound wave.

Page 326

1. The thumb, and first and second fingers are held at right angles. The first finger points in the direction of the field, the second finger in the direction of the current and the thumb gives the direction of the force (movement).

2. Increase the current, increase the strength of the permanent magnets, increase the number of turns on the motor coil. (Reducing the friction on the axle would make the motor spin faster, but it doesn't increase the force, so it doesn't answer the question.)

3. Reverse the direction of the current (by turning the battery round, etc), reverse the polarity of the magnets.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	two of the following: increasing the current flowing through the coil increasing the number of coils adding a soft iron core inside the cardboard tube	2 marks (1 mark for each)
2	when the switch is pressed, the electromagnet attracts the hammer support and the hammer hits the bell the movement of the hammer support breaks the circuit and so the electromagnet ceases to operate the hammer support then returns to its original position, forming the circuit again and the process is repeated	1 mark 1 mark 1 mark 1 mark
3	increase the current increase the number of turns on the coil	1 mark 1 mark
4	bring up a north pole from another magnet if it repels, you have found the north pole of your electromagnet if it attracts, then the pole is a south pole	1 mark 1 mark 1 mark 1 mark
5 a)	there is no force on the particle and it keeps moving in a straight line	1 mark
5 b)	there is a force on the particle which will push it off the straight line	1 mark
6	greater force applied to rotor	1 mark 1 mark
7	several small coils of wire create same effect as one large coil but take up less space	1 mark 1 mark
8	yes if the magnets are the same strength	1 mark 1 mark
9	in a loudspeaker, the coil is attached to a paper cone the changing current in the coil produces a changing magnetic field which interacts with the field from the permanent magnet this creates a 'backwards and forwards' motion of the coil and paper	1 mark 1 mark 1 mark 1 mark 1 mark

Question	Correct answer	Marks
	cone this makes the air vibrate – a sound wave	 1 mark
10 a) i)	the field line is a circle, centred on the wire and passing through P the arrow on the wire should point anticlockwise	1 mark 1 mark
10 a) ii)	the arrow through Q should point to the left	1 mark
10 b) i)	if the current is increased the compass will either not move at all or will move negligibly	1 mark
10 b) ii)	if the current is reversed, the compass will point the other way	1 mark
11	at S the field is stronger at T the field is the same at W the field is the same	1 mark 1 mark 1 mark
	Total:	34 marks

P6d Electromagnetic induction

Page 331 (top)

1. Relative motion between the magnetic field and the wire – a current will flow if there is a complete loop of wire; if there isn't, an emf (voltage) will be generated across the ends of the wire.

2. No, because the wire is not moving.

3. By changing the strength of the magnetic field and/or the speed the wire is moving at.

Page 331 (bottom)

1. A larger current is created.

2. The area of the coil, the number of turns in the coil, the strength of the magnetic field and the speed of rotation.

3. A coil of area 2 m^2.

Page 332

Student's own answer that should cover the following:
Equipment needed: magnet, coil of wire and sensitive meter.
Vary the current by altering the number of coils and the speed the magnet is moved in the coil.

Developing investigative skills, page 333

1. The time period of the spring's oscillation depends on the stiffness of the spring, so if the student sets the spring going from larger extensions the initial speed will be greater, indicating that the method will work. However, as the oscillation loses energy and the amplitude decreases, so the speed will reduce as well. As long as the student is only trying to measure the initial maximum voltage this method will allow measurements to be made. If the student were to use different springs with different spring constants they would also be able to control the speed of the oscillation.

2. The timebase circuit moves the trace across the screen, so if it is switched off the student will see a trace that moves up and down only, reflecting the magnitude of the induced voltage.

3. The deflection of the screen will be positive as the magnet moves in one direction and negative when the magnet moves in the other direction.

4. The screen of the CRO has a grid. The controls of the CRO will indicate how many volts each grid square is ‘worth’. As the trace is deflected the student will be able to judge how many grid squares it moves and so will be able to estimate the maximum voltage.

5. Graph should have a sine wave shape with an amplitude that decreases over time.

6. In this qualitative indicates a more descriptive measurement (bigger, smaller) rather than specific measurements (a quantitative approach).

7. The measurements of speed and voltage could be improved by developing a method that makes some kind of record that can be analysed later, rather than judging by sight as the experiment runs. Data logger and sensors could be used, or record the experiment with a video camera, allowing playback frame by frame at a later time.

Page 334

1. The magnet is rotated inside the coil.

2. The speed of rotation.

3. To maximize the effect, increase the rate of rotation, increase the strength of the magnetic field, increase the number of turns on the coil. The output is an alternating current because the relative motion between coil and field reverses each half-turn.

Page 335

Student’s own answer. A shaver socket contains an isolating transformer, which means that there is no direct link between the current that flows through the shaver and the mains supply.

Page 336

1. To increase the strength of the magnetic field.

2. In a step-up transformer, the output voltage is higher than the input voltage (because the secondary coil has more turns than the primary coil). In a step-down transformer, the output voltage is lower than the input voltage (because the secondary coil has less turns than the primary coil).

3. 20 V

4. 6.0 V

5. a) 24 V

   b) 2 A

   c) 24 A

Page 339

1. Higher voltages mean less energy is wasted in heating the transmission cables, meaning more useful power is delivered at the far end.

2. Transformers change voltages. To send energy at high voltage, firstly the voltage must be increased at the power station end (using a step-up transformer) and then the voltage must be reduced (for safety) at the far end (using a step-down transformer).

3. 40 000 W.

4. 1%.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	iron	1 mark

Question	Correct answer	Marks
1 b)	a magnetic field is produced	2 marks 1 mark
1 c)	a current is induced	1 mark 2 marks
1 d)	$V_p/V_s = n_p/n_s$; $V_p/14 = 12/7$ $V_p = 12/7 \times 14$ = 24 V	1 mark 1 mark 1 mark
2	magnetic field lines being cut; complete circuit	1 mark 1 mark 1 mark
3	for induction, magnetic field must be changing in direct current, magnetic field is constant so there will be no induction in alternating current, magnetic field is changing so there will be induction	1 mark 1 mark 1 mark 1 mark
4	step-down – the voltage must be reduced	1 mark 1 mark 1 mark
5	the magnetic field cuts the secondary, inducing a voltage	1 mark 1 mark 1 mark 1 mark
6	false – a direct current that is switched on and off rapidly can create the required changing magnetic field in the core	1 mark 1 mark 1 mark
7 a)	step-up	1 mark
7 b)	$V_p = V_s n_p/n_s = 800 \times 150 \div 600$ = 200 V	1 mark 1 mark 1 mark
8 a)	any turns ratio 1 : 1.6 such as 100 : 160, 50 : 80, 200 : 320	1 mark 1 mark 1 mark
8 b)	$n_p = n_s V_p/V_s$ = 1600 × 25 000 ÷ 40 000 = 1000	1 mark 1 mark 1 mark
9	at points where the PD is required to be altered such as increasing PD at power station to transmit along power lines	1 mark 1 mark 1 mark

Question	Correct answer	Marks
	and decreasing PD	1 mark
	at substations	1 mark
	so PD suitable for domestic use	1 mark
10	to reduce I^2R losses	1 mark
	since high voltage	1 mark
	means low current	1 mark
	so squared term	1 mark
	as low as possible	1 mark
	so energy lost in transmission as low as possible	1 mark
11	$I_s = I_pV_p/V_s = 20 \times 240 \div 12$	1 mark
	= 400	1 mark
	mA	1 mark
	Total:	52 marks

Section 6: Answers to exam-style questions

Question	Correct answer	Marks
2 a)	suitable lines	1 mark
	not touching	1 mark
	at least one arrow correctly indicating direction	1 mark
2 b)	description of using plotting compass	3 marks
	OR	
	iron filings	
2 c) i)	current generates magnetic field around it	1 mark
	which interacts with existing field	1 mark
	creating a force	1 mark
	which causes movement since the coil is free to spin	1 mark
2 c) ii)	increases magnetic field	1 mark
	which increases force	1 mark
2 c) iii)	reverses direction of magnetic field	1 mark
	which reverses direction of force	1 mark
	Total:	14 marks

Section 7: Radioactivity and particles

P7b Radioactivity

Page 351

1. An atom is what all elements are made of.

2. Electrons and protons have equal and opposite charges and there are equal numbers of them in an atom.

3. Atomic number = number of protons in nucleus (and number of electrons in a neutral atom). Mass number = number of protons + number of neutrons in a nucleus. Isotopes are nuclei with the same atomic numbers, but different mass numbers.

4. Isotopes of an element have the same number of electrons and it is these that determine the chemical behaviour.

Page 353 (top)

The alpha particle is positively charged and so will be deflected towards the negative plate in the electric field. It has a mass of 4, so the deflection will be quite large.

Page 353 (bottom)

1. The emission of particles and/or energy from an unstable nucleus.

2. Unstable.

3. Alpha particles are relatively large, so as they travel they collide often, reducing their energy quickly, so they cannot travel very far. Beta particles are smaller and travel more quickly, having fewer collisions and losing less energy each time. This means they will travel further before losing all their energy. Gamma radiation, being electromagnetic waves, only interacts weakly with matter so it has a much larger range.

4. Alpha and beta particles have an electric charge, but gamma rays are electrically neutral.

Page 354

Student's own answer that should include the following:
Amount of beta radiation picked up by detector is very sensitive to thickness of the paper and so accurate.
Beta radiation is absorbed by a thin sheet of aluminium, so the source can be shielded easily.

Page 355

1. Two protons and two neutrons are emitted. Atomic number reduced by 2 and mass number by 4.

2. A neutron changes into a proton. Atomic number increases by 1. Mass number not affected.

3. No change to the number or types of particles. There is a reduction in energy however.

4. Emitting alpha or beta radiation changes the number of protons in the nucleus. This means the number of outer electrons will also change, changing the chemical behavior – it is a different element.

Page 356

1. Cosmic rays, radiation from rocks, radon gas, radioactive isotopes in the body.

2. Medical sources, consumer products and others.

3. Medical sources.

4. X-rays, gamma rays (from radiotherapy).

5. Nuclear power stations, atomic bombs.

Developing investigative skills, pages 358–359

1. The ionising radiation from radioactive sources can be very harmful and the use of radioactive materials is covered by a range of regulations. Young people are generally not allowed to handle radioactive materials, particularly as young people are still growing and developing rapidly. Reducing the exposure to radioactive materials reduces the risk of any harmful effects to cells in the body.

2. With no radioactive source present, the teacher should take a count rate several times to find a mean background activity. This value should be subtracted from the values measure during the experiment, since this count would have been expected anyway and cannot be due to the protactinium sample.

3. The independent variable was the time since the experiment started, the dependent variable the activity of the sample.

4. Graph is a smooth curve.

5. Depending on the particular curve drawn, the half life should be a little over one minute (actual value for this isotope is 72 s). There should be evidence on the graph of how the value was found – e.g. lines traced across from one axis to the other in two places, where one has half the activity of the other.

6. Random in this context indicates that the behaviour of any individual atom cannot be predicted. Towards the end of the experiment, the values do not follow the pattern exactly, indicating that the randomness of the decay is becoming more significant.

7. The experiment is to investigate the behaviour of the protactinium sample. Background radiation is not connected to the sample, but it will change the measurements made, possibly misleading us into drawing incorrect conclusions about the behaviour of protactinium.

8. To get an accurate value for the half life we need a graph with as smooth a curve as possible – one where we are confident that we have drawn the correct line. The larger the sample of the radioactive source, the higher values our measurements will have and the effect of random variations will be reduced. If we repeat the test and *add all the values together* this would effectively give us a larger sample of the material and should lead to a more accurate value for the half life. However, simply repeating the experiment and averaging the values of half life obtained would not significantly improve the accuracy.

Page 359

1. Radioactivity in soil, rocks and materials like concrete, radioactive gases in the atmosphere and cosmic rays from outer space.

2. Half-life is the time taken for half of the unstable nuclei in a sample to decay: that is, the time for the activity to reduce to half its current level.

3. 2 hours.

4. 4 hours.

5. Activity is 800 Bq now, so in 8 hours it will be 400 Bq. 8 hours later it will be 200 Bq and a further 8 hours later the activity will be 100 Bq. This gives a total of 24 hours, three half lives.

Page 361

Students' own leaflet, for which credit should be given for quality of written communication. The answers to the specific questions are as follows:

1. A radioactive form of glucose.

2. A PET scan produces a high-quality three-dimensional image of the area of the body that is scanned.

3. It is injected into Joe's body.

4. The amount of radiation injected is very small – no more than Joe would receive from a normal X-ray.

5. The radioactive source has a short half−life, which means that the number of radioactive atoms present decreases by half in a short period of time.

6. Cancerous tissues use glucose in a different way from normal tissues, so the image detected by the camera will show the cancerous tumour and how its size has been affected by the treatment that has been given to Joe.

Page 362

1. Sterilising medical equipment and in preserving food.

2. A radioactive substance with a half-life long enough for it to be spread out and be detected. Medical tracers are used to detect blockages in vital organs. Agricultural tracers monitor the flow of nutrients through a plant. Industrial tracers can measure the flow of liquid and gases through pipes to identify leakages.

3. For example: medical uses – gamma tracers, radioactive iodine to target the thyroid gland; non-medical – dating of rocks, smoke detectors.

4. Radioactive emissions are ionising radiations – they can ionise cells in the body which may destroy the cells or damage them (particularly hazardous is the damage involves mutations to the cell which can lead to cancerous changes).

End of Topic Questions mark scheme

Question	Correct answer	Marks
1	completed table as shown below:	12 marks

Atom	Symbol	Number of protons	Number of neutrons	Number of electrons
Hydrogen	$^{1}_{1}\mathrm{H}$	**1**	**0**	**1**
Carbon	$^{12}_{6}\mathrm{C}$	**6**	**6**	**6**
Calcium	$^{40}_{20}\mathrm{Ca}$	**20**	**20**	**20**
Uranium	$^{238}_{92}\mathrm{U}$	**92**	**146**	**92**

Question	Correct answer	Marks
2 a)	11 protons 13 neutrons	1 mark 1 mark 1 mark
2 b)	the count falls from 100 Bq to 50 Bq in 15 hours. It also falls from 50 Bq to 25 Bq in 15 hours 15 hours	1 mark 1 mark 1 mark
3 a)	beta particle	1 mark
3 b)	$x = 24$ $y = 12$	1 mark 1 mark
4	isotopes of an element all have the same atomic number but have different atomic masses because they have different numbers of	1 mark 1 mark

	neutrons in their nuclei	
5	beta particles are high energy (i.e. fast moving) electrons; they are negatively charged and have very little mass	1 mark 1 mark 1 mark
6	ionisation means knocking electrons away from an atom leaving it with a net positive charge (it becomes a positive ion)	1 mark 1 mark
7	${}^{220}_{86}\mathrm{Rn} \rightarrow {}^{216}_{84}\mathrm{Po} + {}^{4}_{2}\mathrm{He}$	3 marks (1 mark for each correct nuclide)
8	${}^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + {}^{0}_{-1}\mathrm{e}$	3 marks (1 mark for each correct nuclide)
9	place each source in turn close (no more than a few cm) to a GM tube connected to a counter place a sheet of paper between each source and the detector for the alpha source only the count rate would fall to the background level as alpha particles are blocked by paper with the remaining two sources repeat the experiment using a sheet of aluminium about 1–2 mm thick if the count falls to the background level you have a beta source as 1–2mm of aluminium will block beta particles but has very little effect on gamma rays	1 mark 1 mark 1 mark 1 mark 1 mark 1 mark
10	in experimental work in schools the activity of materials being investigated is, for health and safety reasons, low. Neglecting to exclude background radiation from your measurements would have a significant effect on their accuracy to do this you would check background radiation level using Geiger counter	1 mark 1 mark 1 mark
11 a)	200 it will have halved twice	1 mark 1 mark
11 b)	4	2 marks
11 c)	3 half-lives so 1 hour 30 minutes	1 mark 1 mark
12 a)	16 counts/min	1 mark 1 mark
12 b)	40 days	1 mark 1 mark
13	8 minutes	2 marks 1 mark
14 a)	about 16 days	1 mark

14 b)	about 50 days	1 mark
14 c)	about 110 days	1 mark
14 d)	about 140 days	1 mark
15 a)	alpha particles	1 mark
15 b)	beta particles	1 mark
15 c)	gamma rays	1 mark
16 a)	a tracer is a radioactive isotope used in detection. Tracers are widely used to detect leaks and blockages	1 mark
16 b)	sodium-24 the lawrencium-257 has too short a half-life; the sulphur-35 and carbon-14 have half-lives which are too long	1 mark 1 mark 1 mark 1 mark
17 a)	lead	2 marks
17 b)	the ratio of uranium-238 to lead-207 enables the age of the rock to be determined	1 mark 1 mark 1 mark 1 mark
	Total:	74 marks

P7c Particles

Page 371

1. Alpha particles only travel a few centimetres in air, so would not reach the gold target. Also, collisions with air particles would cause ionisations which could further alter the detection patterns.

2. Most alpha particles were undeflected, indicating the mass of the atom is mostly concentrated in a small region. It must be a positively-charged nucleus to repel the positively-charged alpha particles. Knowing the mass of the atom and the size of the nucleus, it follows that the nucleus must be very dense material.

3. If electrons formed part of the nucleus it would have no overall electric charge and would not repel alpha particles at all, even those which came close to the nucleus.

4. If electrons had a mass similar to the alpha particles the electrostatic force between them would have a much more noticeable effect on the alpha particles.

Page 373

1. The process where a large nucleus absorbs a neutron and then splits into two large fragments with the release of energy and further neutrons.

2. A lot of energy is given out, the nucleus splits into two parts and some neutrons are emitted.

3. The neutrons released during a fission can collide with further nuclei, causing further fissions which release further neutrons for further fissions, and so on.

Page 375 (top)

1. The control rods absorb some of the neutrons, which prevents them going on to split further nuclei. The number of nuclei that undergo fission is thus controlled and so the energy released is also controlled.

2. Take the control rods out of the core/further out of the core.

3. Move the control rods further into the core.

Page 375 (bottom)

1. Fuel rods – where the fission reaction happens releasing energy as thermal energy.

Control rods – act as 'sponges' absorbing neutrons to control the rate of fission.

Moderator – slows the neutrons down so they are at the correct speed to be absorbed for further fission reactions.

2. By circulating pressurised water or another fluid through the reactor.

3. The waste is radioactive, some of it highly radioactive, so it needs to be handled, transported and stored carefully to reduce the risks to people.

End of Topic Questions mark scheme

Question	Correct answer	Marks
1 a)	alpha particles	1 mark
1 b)	most of the atom is empty space	1 mark 1 mark 1 mark
1 c)	the atom must have a very high concentration of mass and positive charge Rutherford called this the nucleus	1 mark 1 mark
2	all matter is made of atoms, but Geiger and Marsden showed that almost all the volume taken up by an atom is empty – only in a tiny space at the centre (the nucleus) and at some extremely small spots around the centre (the electrons) is there any material at all	1 mark 1 mark 1 mark 1 mark
3	in nuclear fission, an unstable atom is triggered into splitting apart by absorbing a neutron	1 mark 1 mark 1 mark
4	the fission of uranium-235 produces two lighter nuclei plus three neutrons – each of these neutrons can trigger another atom to split	1 mark 1 mark 1 mark
5	the reaction proceeds with increasing speed as more and more neutrons are produced by fission, setting off further fissions at the same time the amount of energy produced as heat is rapidly increasing rapidly making the task of controlling the chain reaction	1 mark 1 mark 1 mark

Question	Correct answer	Marks
	impossible	
6	the massive and rapid release of huge amounts of energy	1 mark 1 mark 1 mark
7	by controlling the rate of the fission reaction so that it proceeds at a self-sustaining but much slower rate this is done using control rods to absorb neutrons so the rapid escalation cannot occur	1 mark 1 mark 1 mark
8	as a nucleus splits, it releases energy; because the energy of the nucleus before the fission is greater than the combined energy of the two daughter nuclei in a chain reaction this amount of energy is multiplied many times and so a great deal of energy is released in a chain reaction	1 mark 1 mark 1 mark 1 mark 1 mark 1 mark
9	in a nuclear power station, neutrons collide with U-235 nuclei which leads to fission of the nuclei; some of the neutrons produced in the fission reaction are absorbed by control rods to prevent the reaction from getting out of control	1 mark 1 mark 1 mark 1 mark 1 mark 1 mark
10 a) i)	no evidence, just a statement: ‘add to that impact on the local environment’	1 mark 1 mark
10 a) ii)	company spokesperson says emissions are water vapour and steam which is cleaner than emissions from coal-fired	1 mark 1 mark
10 a) iii)	concerns over disposal of waste, fear of the unknown	1 mark 1 mark
10 b)	students’ own opinions - give credit for well-balanced views supported by scientific knowledge	6 marks
10 c)	students’ own research	6 marks
	Total:	55 marks

Section 7: Exam-style questions mark scheme

Question	Correct answer	Marks
2 a)	(nuclear) fission	1 mark
2 b)	kinetic energy of the particles made	1 mark 1 mark
2 c)	neutrons released	1 mark

	can collide with further nuclei causing further fissions	1 mark 1 mark
2 d) i)	absorb neutrons controlling rate of fission	1 mark 1 mark
2 d) ii)	slow down neutrons allowing them to be absorbed	1 mark 1 mark

